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THE USE OF LIABILITY RATINGS IN PLANNING FOREST FIRE PROTECTION [1]

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INTRODUCTION

Two main objects were in view in undertaking this study. In the first place, it was desired to ascertain if some scientific method could be found by means of which it would be possible to determine how much money can justifiably be spent for fire protection on the national forests. The second object was to provide a basis for the proper distribution of available protection funds between the different units of the organization.

The results of the study seem to indicate that so far, with the inadequate data available, no absolute mathematical rules or formulae can be established to fulfill either of these purposes. Scientifically accurate formulae require accurate basic data, which can be gained only through years of intensive research, and through detailed records, carefully kept for a considerable period. Moreover, the correct application of such formulae would require accurate detailed knowledge of the resources that we want to protect, which can be gotten only by means of intensive survey and mangement plans for the entire national forest area.

It is believed, however, that the study, even though based on admittedly unsatisfactory data, has yielded some material which, supplemented by a fire plan reconnaissance, will be of considerable value both in helping to determine the total amount of expenditures justifiable, and in distributing allotments within the organization. As better data accumulate, upon which to base more reliable figures than those worked out in the following pages, they will become more useful for these purposes. It is extremely important that such data be collected and kept as permanent records so that they may be utilized as the basis for future research.

BASIC PRINCIPLE GOVERNING EXPENDITURES

The best measure by which to judge the sufficiency of any fire protection organization is the net result accomplished. This net result may be expressed in terms of cost of protection plus losses incurred in spite of protection; and the smaller this sum, the more efficient the protection. As one factor, cost of protection, goes up when the other, loss, goes down, it is evident that there will always be some point below which the sum can not be reduced. Up to this point, expenditures for protection are justifiable.

Since the object in view is to reduce the sum of cost plus loss to a minimum, and not to eliminate all loss, regardless of cost, it is evident that justifiable costs should be determined by weighing against them the losses likely to be incurred.

Protection costs are in two distinct categories. One, which may be called primary protection, includes the cost of the organization for prevention, detection, and suppression (including personnel, equipment, and improvements), and is determined in advance. The second includes actual costs of suppression, such as temporary labor, subsistence, and transportation, as well as the time of forest officers taken off from other work. These costs, like losses, can not be determined in advance, but together with the losses depend upon the occurrence of fires. They can not, or should not, be limited by the arbitrary allotment of funds in advance, because with exceedingly few exceptions all fires must be fought, the question of "how soon" being answered by weighing probable losses plus suppression costs against the expenditures required to attack them within given periods. Even in the case of open lands with low liability, it

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will usually be necessary to suppress fires to keep them from running over on lands with greater liability, or because of the consequent effect on the fire hazard in general.

The principle may be illustrated by a diagram (fig. 1), which shows the curve for loss plus suppression costs (X-Y) descending as the line representing primary protection costs (A-B) rises, while the curve S-T, representing the sum of the two, falls to a point P, then rises steadily. The expenditure at which P is attained, or E, represents the proper amount to spend for primary protection. A greater expenditure might indeed reduce the loss and suppression cost, but not sufficiently to reduce the total, and so might not be justified.

The purpose of this study, then, was to determine whether it is possible to rate the liability of loss as well as the probable cost of suppression, which together may be termed the total liability. No attempt was made to actually rate the fire hazard and liability for specific forest units, but principles and methods have been worked out as a basis for a detailed field survey or "fire reconnaissance," which must necessarily lie at the foundation of any rating for specific forest units.

FACTORS OF HAZARD AND LIABILITY

The probability of loss is governed primarily by the values of destructible resources, and by the hazard, or chance of their destruction as a result of exposure to fire. Values of forest resources may be classified under the following heads: (1) Timber, including mature timber, young growth, and the forest capital, which includes soil productivity; (2) forage; (3) indirect values, including watershed protection (regulation of streamflow and prevention of erosion and floods) and occupancy values, such as recreational use, improvements, game resources, and the like.

FIRE HAZARD

The chance of destruction by fire of the values on a given forest area depends upon the probability of its being burned over, and upon the probability that the values will be destroyed as a result of such burning. Its chance of being burned over depends upon whether fires will start on or near it, and upon the area that such fires will cover.

Whether or not fires will start depends upon the presence or absence of causative agencies during the period in which fires can start. These agencies may be classified as follows:

Human agencies: Campers (including campfires and fires caused by smokers and hunters), lumbering operations, railroads, brush burning, incendiaries, and miscellaneous.

Natural agencies: Lightning.

The area that will be burned over depends upon a large number of factors and subfactors, which may be outlined as follows:

1. Inflammability determines rate of spread, and depends upon the character of:

a. Cover, including timber, undergrowth, and litter, all of which furnish the fuel for fires. Inflammability of timber depends upon the species, age, density, and uniformity of the stand; and the condition of the stand, including such points as the presence of catfaces, moss on the trunks and lower branches, and standing dead snags. Inflammability of the undergrowth depends upon its character (grass, weeds, brush, or tree reproduction), amount (density and height), and uniformity of distribution. Inflammability of the litter is determined by its character (duff, dead grass and herbage, needles, twigs, cones, branches, logging slash, windfalls), its amount, and its condition as to dryness, decay, compactness, etc.

b. Climate and weather, which not only have much to do with determining the character and condition of the cover, but also influence directly the action of fires. The important climatic factors are: (1) Precipitation, both annual and seasonal, especially its amount and distribution during the dry seasons; (2) temperatures, means and maxima, especially during dry parts of the year; (3) humidity, including fogs, dews, etc., during the dry seasons; (4) evaporation, affecting the rate of drying of inflammable material; (5) soil moisture; (6) wind direction and velocity during the dry season.

c. Topography, which with climate practically determines the character of cover, and also directly affects the spread of fires, by the degree of slope, by the aspect, by the uniformity of terrain, and by the absolute and relative altitude, which influence atmospheric factors.

2. Controllability determines whether fires can be extinguished while small, or whether they will burn over large areas. It depends upon:

a. Men and equipment available to fight fires.

b. Accessibility—the time required to detect and to reach a fire, together with the routes and possible methods of travel.

c. Topography and soil, which influence the speed and cost of control work, such as trenching. Natural breaks, such as cliffs, streams, and bare ridges, and artificial breaks, such as roads and fire lines, should be considered here, as may also the availability of water for use on the fire line.

d. Type of forest and ground cover, which influence the method of attack, as well as the speed and cost of the work.

e. Degree of efficiency with which suppression work is carried on.

Even though a given area of forest may burn over, it does not necessarily follow that all or even a major part of the values on the burned area will be destroyed. The chance of destruction, which may be called the loss ratio, or the destructibility, depends upon the susceptibility of the various resources to direct and indirect fire damage, and also upon the intensity of the fire. These in turn depend upon

several factors, chief of which is the type of cover. The type of cover involves kind, age, density, and condition of the timber and other cover, and the amount and condition of duff and litter. The kind and depth of soil not it will be a surface, ground, or crown fire.

COST OF SUPPRESSION

Cost of suppression may also be considered as a resultant of fire hazard,

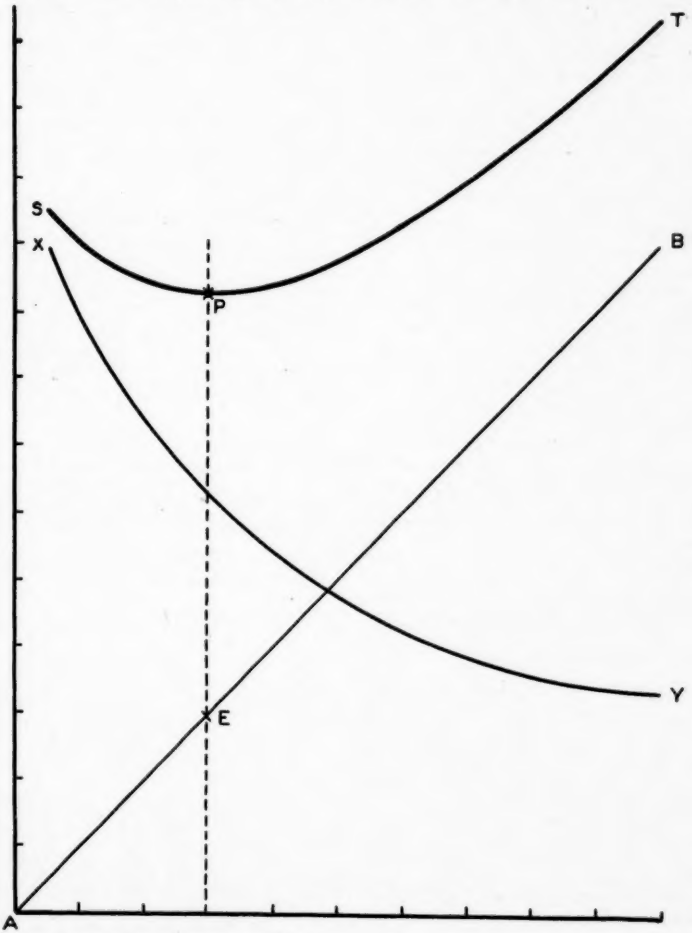

FIG. 1.—AB represents primary protection cost
XY represents sum of suppression cost plus losses "or total liability"
ST represents sum of AB plus XY
E marks the point of proper primary protection cost, where sum of all costs plus losses is at its lowest point P

is also important, because of its relation to forest productivity as well as to the watershed protection values. All of the factors listed above under inflammability influence the intensity of the fire, and determine whether or since it is determined very largely by the same factors that govern the inflammability and controllability. It is also affected by variation in wage rates and in costs of tools and subsistence, and by differences in degree of efficiency.

COST OF PRIMARY FIRE PROTECTION

Against the sum of loss plus suppression cost or total liability, we must balance protection cost—what for the sake of convenience has been termed primary protection, to distinguish it from the cost of fire suppression. This is the known quantity—the amount that is figured in advance when a definite organization is developed to prevent, detect, and control fires. There is a certain overlapping here, unless we leave out of consideration in the suppression cost the services rendered by the primary protection organization already provided for in advance. It was not practicable to make this separation in the present study; hence the suppression costs as determined, and given in the accompanying tables, include some of the cost of the primary protection organization. The more intensive the organization, the greater will be the proportion of fires handled by it without calling on outside help; consequently the real saving in liability with decrease in hour-control will tend to be somewhat greater than the differences between suppression costs indicate. The cost of primary protection will be determined by the length of the period during which it is in effect, which depends upon the length of danger season, by the number of men, and amount of equipment used for the purpose, and by salary rates and costs of maintaining equipment.

BASIS FOR STUDY

The problem of developing a method for rating hazard and liability requires study of the relations between the various combinations of factors that may be found in different units, and of the results in losses plus suppression costs. The only scientific basis for such a study is what has actually happened, that is, the actual fire history of the different forest areas. For this purpose, the present study made use of the available records of individual fires that occurred on the national forests during the period 1911–1915 (summarized in Table I). Records previous to 1911 are too incomplete or inaccurate to be useful, and those for years after 1915 were not available at the time the study was undertaken. Records for some national forests for some of the years between 1911 and 1915 are missing. The records for subsequent years should be studied in addition to those already used, to follow up the methods for rating hazard and liability outlined in the following pages. Figures based on 10 or more years should be much more reliable than those based on only 5 years, not only because the longer period gives a much better average than does the shorter (and it is known that climatic conditions were more dangerous and fires more numerous and destructive during the 5 years following 1915), but also because the later records are more complete and accurate than the earlier ones. Only fires that burned on national forest land were used, because the records of others are less complete and, for several reasons, not comparable. Moreover, without data regarding the areas of different forest types on private lands both within and outside the forest, it would be impossible to relate either numbers of fires or areas burned over to the total acreage exposed to fire danger. (See Tables II and III.)

The records do not give detailed information regarding most of the factors whose effect it is desired to study, and even if such data were available, it seems probable that to consider them all separately would so complicate the problem that it could not be solved. Even if methods for rating could be worked out, to apply them would require us to rate nearly every individual

TABLE I.—*Fires on national forest land (1911–1915) used as a basis for study*

Region	Fires due to general risk			Fires due to special risk		
	Number of fires	Area burned	Average area per fire	Number of fires	Area burned	Average area per fire
		Acres	*Acres*		*Acres*	*Acres*
1	50	4,474	79.9	103	215	2.1
2	382	32,858	86.0	236	350	1.5
3	904	26,008	28.8	155	309	2.0
4	326	27,992	85.9	6	95	15.8
5	82	15,431	188.2	20	680	34.0
6	1,984	77,823	39.2	17	39	2.3
7	723	33,246	46.0	20	79	4.0
8	714	83,306	116.7	16	595	37.2
9	170	9,199	54.1	27	46	1.7
10	218	18,063	82.9	3	3	1.0
11	406	20,703	51.0	103	2,234	21.7
12	108	359	3.3	80	418	5.2
13	120	1,748	14.6	101	1,385	13.7
14	53	2,832	53.4	1	15	15.0
15	117	15,415	131.8			
16	1,093	56,515	51.7	100	3,418	34.2
17	605	148,141	244.9	38	2,582	68.0
18	1,308	121,913	93.2	154	1,435	9.3
19	250	4,637	18.5	113	2,200	19.5
20	187	22,224	118.8			
21	121	25,674	212.2	181	5,638	31.1
Totals	9,927	748,561	75.4	1,474	21,736	14.7

TABLE II.—*Approximate areas of forest types by regions* [a]

Region	Areas in thousands of acres by forest types													
	Western yellow pine	Western yellow pine, sugar pine, incense cedar	Douglas fir and larch	Lodgepole (and knobcone) pine	Spruce	Fir, hemlock, and cedar	White pine	Subalpine	Aspen	Pinon-juniper and oak-digger pine	Hardwood	Brush	Grass and sage	Total net national forest area
1	48	------	477	1,108	66	------	------	412	------	------	------	(b)	383	2,745
2	891	------	1,837	1,957	315	------	133	1,230	------	------	------	(b)	325	6,948
3	272	------	1,882	217	188	69	1,128	689	------	------	------	(b)	553	5,079
4	906	------	1,229	409	240	301	------	807	------	------	------	(b)	128	4,390
5	2	------	3,571	123	------	1,655	------	1,887	------	------	------	1,331	(b)	8,470
6	597	1,303	1,935	124	------	346	------	95	------	210	------	1,615	97	6,441
7	(b)	2,352	183	620	------	402	------	340	------	477	------	413	427	5,296
8	3,539	------	2,843	2,207	366	77	------	1,511	1	------	------	498	1,200	12,561
9	2	------	952	2,214	86	------	------	917	26	------	------	(b)	1,408	6,076
10	35	------	1,156	3,510	576	------	------	1,399	550	18	------	(b)	3,757	12,470
11	1,448	------	------	------	6	------	------	------	------	------	------	(b)	348	1,803
12	859	------	65	440	836	------	------	16	40	45	------	20	156	2,850
13	2	------	28	1,512	1,297	------	------	(b)	1,051	35	------	212	797	5,298
14	206	------	327	615	646	------	------	117	806	831	------	838	654	5,352
15	183	------	43	102	60	339	------	(b)	490	2,925	------	866	2,425	7,816
16	865	1,720	60	333	------	455	------	447	------	213	------	1,143	129	6,308
17	------	336	111	------	------	------	------	6	------	------	144	2,726	39	3,376
18	5,433	------	(b)	------	(b)	------	------	(b)	(b)	3,259	------	5,179	(b)	13,871
19	4,739	------	(b)	230	(b)	------	------	(b)	743	713	------	1,598	(b)	8,682
20	578	------	(b)	------	(b)	------	------	(b)	------	2,409	------	554	(b)	3,541
21	------	------	------	543	130	80	160	------	(b)	------	185	(b)	30	1,128
Total	20,605	5,711	16,699	[c]16,264	4,812	3,724	[d]1,421	9,873	3,707	11,135	329	16,993	12,856	130,501

[a] These are in many cases based on very rough estimates.
[b] Indicates area included with some other type. Totals for each region do not in most cases agree with sums of figures for separate types, because barren areas are also included in totals (sometimes barren is included in brush, grass, or subalpine).
[c] Includes 543,000 acres jack pine in Region 21. [d] Includes 160,000 acres white and red pine in Region 21.

TABLE III.—*Percentages of total areas of different types burned over each year; averages for 5-year period, 1911–1915* [a]

Region	Commercial timber types								Nonmerchantable types [b]						All types
	Western yellow pine	Western yellow pine, sugar pine, incense cedar	Douglas fir and Douglas fir-larch	Lodgepole pine	Spruce, cedar, hemlock, and firs	White pine	Hardwoods	Total commercial timber types	Subalpine	Aspen	Pinon-juniper and digger pine-oak	Chaparral and brush	Grass and sage	Total	
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1	(c)	------	0.007	0.066	------	------	------	0.045	(c)	------	------	------	0.034	0.015	0.033
2	0.067	------	.199	.099	0.047	0.053	------	.125	0.009	------	------	------	.017	.010	.095
3	.037	------	.076	.007	.475	.198	------	.133	.025	------	------	------	.004	.016	.102
4	.128	------	.441	.108	.418	------	------	.345	.012	------	------	------	1.418	.044	.245
5	------	------	.139	------	.515	------	------	.210	.016	------	------	0.318	------	.281	.246
6	.063	0.273	.497	.163	.305	------	------	.304	(c)	------	0.081	.494	.137	.390	.329
7	------	.278	------	.255	.047	------	------	.242	.012	------	.001	.337	.278	.141	.196
8	.440	------	.210	.108	(c)	------	------	.236	.015	------	------	.003	.354	.114	.207
9	------	------	.041	.031	.168	------	------	.038	.002	------	------	------	.066	.042	.037
10	.146	------	.043	.009	.009	------	------	.018	(c)	------	------	------	.066	.050	.031
11	.257	------	------	------	------	------	------	.257	------	------	------	.116	------	.116	.230
12	.006	------	.008	(c)	(c)	------	------	.003	(c)	0.005	------	------	.002	.002	.003
13	------	------	.079	.008	.003	------	------	.006	------	.004	------	------	.016	.009	.007
14	.003	------	(c)	(c)	(c)	------	------	(c)	(c)	(c)	(c)	.042	------	.020	.012
15	.015	------	.003	.001	(c)	------	------	.004	------	(c)	.009	.017	.112	.046	.040
16	.265	.079	------	(c)	.021	------	------	.110	.021	------	.656	.452	.663	.395	.196
17	.269	------	.870	------	------	------	0.022	.322	.003	------	------	.985	2.122	.999	.878
18	.385	------	------	------	------	------	------	.385	------	------	.024	.018	------	.020	.180
19	.014	------	------	.002	------	------	------	.014	------	------	.001	.006	------	.005	.011
20	.438	------	------	------	------	------	------	.438	------	------	.050	.128	------	.064	.125
21	------	------	------	[d].683	(c)	.574	.145	.445	------	------	------	------	.817	.817	.455

United States average: 86,878 acres out of 55,971,000 acres timber=0.155 per cent; 58,718 acres out of 47,839,000 acres noncommercial=0.123 per cent; 145,596 acres out of 103,810,000 for all types=0.140 per cent.

[a] Based on incomplete records for some regions, especially Washington and Oregon.
[b] Open and woodland types often combined; figures given apply to two or more types combined.
[c] Less than $\frac{1}{1000}$ of 1 per cent. [d] Jack pine. [e] None burned.

TABLE IV.—*Important climatic characteristics of the several national forest subregions* [a]

Region	Precipitation			Temperature			Length of growing season	Prevailing winds during fire season	Characteristic types of forest
	Total annual (average and range)	July and August	Rainy days (over 0.01 inch)	Mean annual	Mean maximum	Days per year above 90° F.			
	In.	*In.*	*No.*	*° F.*	*° F.*	*No.*	*Days*		
1	13(10–15)	2.0	95	44	55	6–13	150	W., SW	LP.
2	16(15–20)	2.0	100	43	54	1–2	130	W., SW	YP, WL–DF.
3	33(25–40)	2.5	120	43	55	5–6	115	S., SW	WP.
4	14(10–30)	0.7	60	47	58	8–16	120	S	YP, WL–DF.
5	64(37–140)	1.7	150	51	60	1–11	210	W., SW	DF.
6	44(35–70)	1.8	115	53	65	0–8	200	NW	DF, redwood.
7	14(8–23)	0.6	65	46	62	8–39	130	S., NW. [b]	YP.
8	16(15–35)	0.8	70	49	61	4–34	135	S., NW. [c]	YP.
9	13(10–15)	1.2	65	41	55	1–17	[d] 90	W., NW	LP, DF.
10	15(10–20)	1.7	75	39	52	0–6	[e] 85	S., SE.; W., SW. [f]	LP.
11	17(12–25)	5.0	75	44	55	5–29	150	N., NW.; E., SE. [g]	YP.
12	13(10–15)	2.0	60	46	62	2–29	125	N.; SE. [h]	YP, LP.
13	15(9–27)	2.7	90	39	55	0–20	100	N	LP, ES.
14	12(8–16)	1.5	60	48	62	12–47	140	SW., W	DF, ES.
15	9(7–12)	1.5	50	46	62	19–51	[i] 115	SW., S	Pinon, juniper.
16	49(35–80)	2.2	70	50	(*j*)	(*j*)	120	S., W., NW	YP–SP–IC.
17	14(10–20)	1.6	35	62	70	1–15	300	W., NW	Chaparral.
18	14(8–18)	[k] 1.4	60	54	70	16–51	160	E., S, SW	YP.
19	12(7–16)	[k] 2.1	55	50	66	2–79	[l] 155	W., SW	YP.
20	13(9–16)	[k] 1.1	55	62	75	46–80	230	N., NW	Woodland, YP.
21	32(27–35)	[m] 4.0	[n] 90–120	[o] 37–41	[p] 49–52	1–10	[q] 105–130	N., S., SW.; SE. [r]	WP, jack pine.

[a] Data based on Bulletin Q, Weather Bureau, United States Department of Agriculture.
[b] S. in southern part, NW. at north end.
[c] NW. and S. in western part, S. and SW. in east.
[d] Range, 55 to 120 days.
[e] Range, 65 to 105 days.
[f] SE. and S. in northwest, W. and SW. in south.
[g] E. and SE. in May.
[h] SE. in May, July, August, September.
[i] Range, 95 to 130 days.
[j] Data lacking.
[k] Figures are for April–May–June.
[l] Range, 130 to 180 days.
[m] Figures are for October–November.
[n] Minnesota, 90 days; Michigan, 120 days.
[o] Minnesota, 37°; Michigan, 41°.
[p] Minnesota, 49°; Michigan, 52°.
[q] Minnesota, 105 days; Michigan, 130 days.
[r] Minnesota, N. in spring, S. and SW. summer and fall; Michigan, SE. in spring and fall.

acre separately. If, however, numbers of factors can be grouped together in such a way as to reduce the number of items that must be considered in rating, and so as to make it possible to use the data concerning the history of past fires, which are already at hand or obtainable, it may be possible to develop a method that can be applied. This involves the principle of classification of risks, somewhat analogous to that used in the insurance business, where rating is based on the probable losses for a class of risks, rather than for each individual risk separately.

CLASSIFICATION OF RISKS

The object of such a classification should be to throw together into one class all forest tracts whose factors of risk are so substantially similar that the probable fire loss and suppression cost per unit of area, over a period of years, will be fairly uniform. Because of the nature of the data available for study, and also in order that ratings can be applied in working out actual protection organizations, the classification must be along rather broad lines, with a minimum of detail. Accordingly, the following general scheme was followed:

1. To allow for general difference in climatic and seasonal factors and the resultant differences in general forest conditions, the western national forest region, exclusive of Alaska, was divided into 21 subregions, mainly on the basis of climatic characteristics. (See Table IV and figs. 2 and 3.) These subregions are as follows:

1. Northern Rocky Mountains.
2. Western Montana.
3. Northern Idaho.
4. Eastern Washington.
5. Western Washington and Oregon.[2]
6. Southern Oregon and Northern California Coast Ranges.
7. Southeastern Oregon and northeastern California.
8. Eastern Oregon and southwestern Idaho.

[2] The study did not cover Alaska or the eastern national forests.

9. Central Idaho and southwestern Montana.
10. Yellowstone plateau region.
11. Black Hills and eastern Montana.
12. Eastern Colorado.
13. Northwestern Colorado and southern Wyoming.
14. Wasatch and Uinta Ranges.
15. Interior desert region—mostly Nevada.
16. West slope of Sierras.
17. Southern California.
18. Colorado Plateau region.
19. Northern New Mexico and southwestern Colorado.
20. Southern Arizona and New Mexico.
21. Lake States.[2]

values, fire hazard, and cost of suppression. The grouping of types within each region is shown in Table V. Such a classification is crude, it is realized, since it does not allow for such factors as age of stand or for the wide local variations in inflammability of individual stands of a given type, due to such factors as the presence of logging slash or other débris. Ratings obtained, therefore, will represent aver-

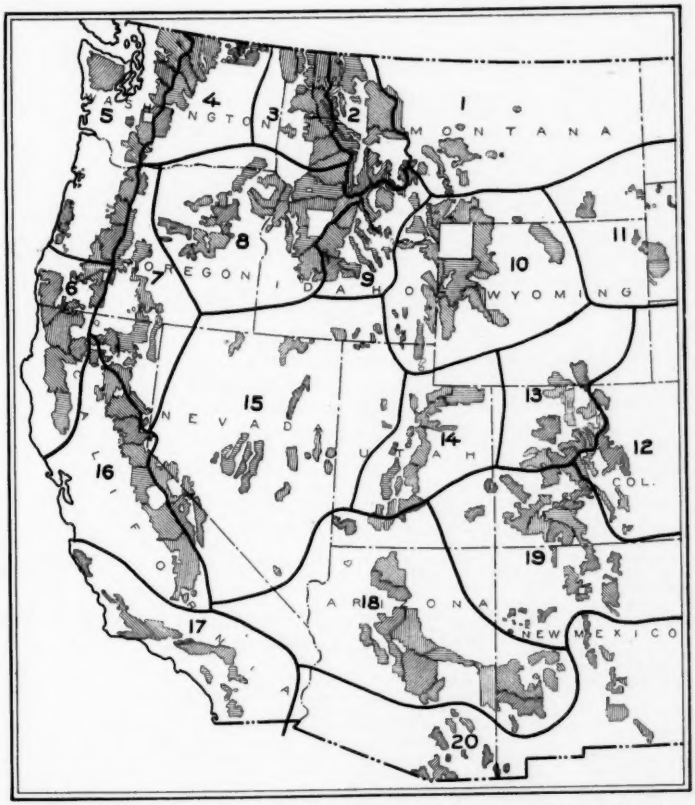

FIG. 2.—Subregions used in studying fire hazard. (Region 21, Lake States, not shown)

2. Within each of these regions it seems reasonable to assume that a given type of forest is in a broad way fairly uniform in its composition and general characteristics, so that within the region classification of the forest areas according to type of cover will in a general way allow for variations in the factors which determine total and destructible

ages of fairly broad application, but may not show what can be expected on individual small units. These factors can be allowed for only when the fire records and the inventory of our forest resources include information concerning them. It is hoped that this can be done in future work.

[2] The study did not cover Alaska or the eastern national forests.

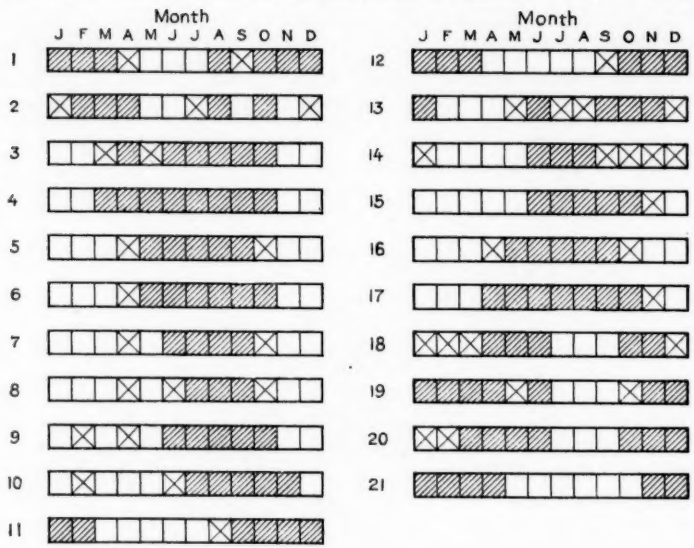

FIG. 3.—Distribution of precipitation by months, for the several forest regions

TABLE V.—*List of subregions and forests, with the classification of forest types* [a]

Region	Forests	Forest types	Representative weather stations
1. Northern Rocky Mountains.	Lewis and Clark, Helena (except west end), Jefferson, Gallatin (northern part), Absaroka (northern part).	Douglas fir, lodgepole pine, subalpine (including Engelmann spruce), open (grass, sage, etc.).	Helena, Great Falls.
2. Western Montana.	Blackfeet, Bitterroot, Flathead, Missoula, Helena (W.), Deerlodge (N.), Kootenai (E. of range 31 W.), Cabinet (E. of range 29 W.), Lolo (E. of line from NE. of T. 19–28 to NW. of T. 17–29).	Western yellow pine, Douglas fir–western larch, lodgepole pine, spruce-cedar-hemlock-white fir, western white pine, subalpine, open (grass, sage, etc.).	Kalispell, Missoula.
3. Northern Idaho....	Kaniksu, Pend Oreille, St. Joe, Coeur d'Alene, Kootenai (W.), Clearwater, Cabinet (W.), Selway (Lochsa drainage), Lolo (W.).	Same as Region 2, with "open" separated into "brush" and "grass."	Priest River, Porthill, Murray, Wallace, Sandpoint, Spokane.
4. Eastern Washington.	Colville, Okanogan, Chelan, Wenatchee, Rainier (E.), Columbia (E.).	Same as Region 3, except that western white pine not used.	Ellensburg, Colfax, Lakeside, Spokane, Lyle.

[a] Common and botanical names for the species listed here and mentioned elsewhere in this article are as follows: Western yellow pine (*Pinus ponderosa*), sugar pine (*P. lambertiana*), jack pine (*P. banksiana*), western white pine (*P. monticola*), lodgepole pine (*P. contcrta*), eastern white pine (*P. strobus*), red or Norway pine (*P. resinosa*), Jeffrey pine (*P. jeffreyi*), pinon pine (*P. edulis*), digger pine (*P. sabiniana*), Douglas fir (*Pseudotsuga taxifolia*), bigcone spruce (*Ps. macrocarpa*), lowland white fir (*Abies grandis*), red fir (*A. magnifica*), balsam (*A. balsamea*), Engelmann spruce (*Picea engelmanni*), white or eastern spruce (*P. canadensis*), black spruce (*P. mariana*), western larch (*Larix occidentalis*), tamarack (*L. laricina*), western hemlock, (*Tsuga heterophylla*), juniper (*Juniperus* spp.), redwood (*Sequcia sempervirens*), incense ceder (*Libocedrus decurrens*), red cedar (*Thuja plicata*), aspen (*Populus tremuloides*).

TABLE V.—*List of subregions and forests, with the classification of forest types*—Con.

Region	Forests	Forest types	Representative weather stations
5. Western Washington and Oregon.	Mt. Baker, Snoqualmie, Olympic, Rainier (W.), Columbia (W.), Mt. Hood, (W.), Umpqua (N.), Santiam, Siuslaw, Cascade.	Lower slope (Douglas fir, cedar, hemlock, spruce, etc.), upper slope (true firs, hemlock, etc.), subalpine.	Olympia, Snohomish, Centralia, Portland, Seattle, Albany, Glenora.
6. Southwest Oregon and northwest California.	Umpqua (S.), Crater (W.), Siskiyou, Klamath, Trinity, California, Shasta (W.).	Western yellow and sugar pine, Douglas fir, red and white firs, subalpine, oak and digger pine, brush fields, grass.	Ashland, Roseburg, Eureka, Sisson, Ukiah, Weaverville.
7. Southeastern Oregon and northeastern California.	Oregon (E.), Deschutes, Fremont, Crater (E.), Modoc, Shasta (E.), Lassen (E.), Plumas (E.), Tahoe, (E.).	Western yellow and sugar pine, lodgepole pine, fir, subalpine, woodland, brush, grass and sage.	Prineville, Dayville, Lakeview, Silver Lake, Cedarville, Susanville, Reno.
8. Eastern Oregon and southwestern Idaho.	Ochoco, Malheur, Umatilla, Wallowa, Whitman, Minam, Wenaha, Nez Perce, Selway (S.), Weiser, Idaho, Payette, Boise, Salmon (N. and W.), Sawtooth (W.).	Same as Region 2, except no white pine.	Walla Walla, Pomeroy, Baker, Joseph, Payette, Boise.
9. Central Idaho and southwestern Montana.	Sawtooth (E.), Salmon (E.), Challis, Lemhi, Beaverhead, Deerlodge (S.), Madison (N.).	Douglas fir, lodgepole pine, Engelmann spruce, subalpine, brush, grass and sage.	Butte, Soldier.
10. Yellowstone Plateau.	Madison (S.), Gallatin (S.), Beartooth, Absaroka (S.), Shoshone, Bighorn, Bonneville, Bridger, Washakie, Teton, Targhee, Palisade, Wyoming, Caribou, Cache, Pocatello.	Same types as Region 9.....	Henrys Lake, Yellowstone Park, Thayne, Lander.
11. Black Hills and eastern Montana.	Black Hills, Harney, Sioux, Custer.	Western yellow pine, open (brush and grass).	Miles City, Oakdale, Spearfish.
12. Eastern Colorado.	Colorado, Pike, San Isabel, Leadville (S.).	Western yellow pine, Douglas fir, lodgepole pine, Engelmann spruce, subalpine, open (brush, grass, and woodland).	Fort Collins, Denver, Colorado Springs, Salida, Saguache, San Luis.
13. Northwestern Colorado and southern Wyoming.	Hayden, Routt, White River, Sopris, Battlement, Medicine Bow, Arapahoe, Holy Cross, Leadville (N.)	Douglas fir, lodgepole pine, Engelmann spruce, subalpine, aspen, brush, grass.	Laramie, Cheyenne, Rawlins, Walden, Meeker, Pagoda, Breckenridge.
14. Wasatch and Uinta Ranges.	Ashley, Uinta, Manti, Powell (N.), Fillmore, Fishlake, Sevier (N.), Wasatch (exc. W.).	Western yellow pine, Douglas fir, lodgepole pine, Engelmann spruce, subalpine, aspen, pinon-juniper, brush, grass, and sage.	Vernal, Provo, Salt Lake.
15. Interior desert region (Nevada).	Minidoka, Humboldt, Santa Rosa, Nevada, Wasatch (W.), Mono, Ruby, Toiyabe, Moapa, Inyo.	Western yellow pine, lodgepole pine, Douglas fir, red and white fir, pinon-juniper, brush and chaparral (including aspen and mahogany), grass and sage.	Winnemucca, Potts, Elko, Ely, Oakley, Idaho, Independence, Calif.
16. West slope of Sierras.	Sequoia, Stanislaus, Tahoe (W.), Lassen (W.), Sierra, Eldorado, Plumas (W.), Shasta (S., center.)	Western yellow and sugar pine, red and white fir, lodgepole and knobcone pines, subalpine, oak and digger pine, brush fields, grass and open.	Auburn, Sisson, Summit, Laporte, Yosemite, Quincy.
17. Southern California.	Monterey, Santa Barbara, Angeles, San Bernardino, Cleveland.	Western yellow and Jeffrey pine, fir and pine slopes, subalpine, hardwood bottoms, chaparral, grass, sage, desert.	San Diego, Redlands, Los Angeles, Santa Barbara, Santa Cruz, San Bernardino.
18. Colorado Plateau..	Sevier (S.), Powell (S.), Coconino, Prescott, Apache, Datil, Crook (N.), Dixie (except Moapa), Kaibab, Tusayan, Tonto, Sitgreaves, Gila.	Western yellow pine, Douglas fir mixed, spruce and subalpine, pinon-juniper, brush and aspen, sage and grass.	Holbrook, Prescott, Fort Apache, Fort Bayard.
19. Southwestern Colorado and northern New Mexico.	LaSalle, Gunnison, Rio Grande, Durango, Carson, Manzano (W.), Uncompahgre, Cochetopa, Montezuma, San Juan, Santa Fé.	Same as Region 18, with addition of lodgepole pine at north end.	Moab, Utah; Durango, Colo.; Aztec, N. Mex.; Santa Fé; Fort Wingate.
20. Southern Arizona-New Mexico.	Manzano (E.), Coronado, Lincoln-Alamo, Crook (S.).	Same as Region 18.....	Mesilla Park, Tucson, Dudleyville, Fort Huachuca.
21. Lake States.....	Minnesota, Superior, Michigan.	Eastern white and red pines, jack pine, spruce, balsam, tamarack, hardwoods, grass and open.	Sault Ste. Marie, Park Rapids, Grayling, Mount Iron.

3. The causes of fire may be classified as "general" or "blanket" risks, and "special" or "local," sometimes called "fixed" risks. The latter include such causes as railroads, lumbering operations, and brush burning, whose locations are definitely fixed within certain restricted known localities. Some camper fires might also be included in this class, because they are localized along established travel routes or at established camp sites. Since, however the data contained in the fire records do not permit segregation of such fires from the other camper fires, they are all thrown together with fires caused by lightning, incendiaries, miscellaneous, and unknown causes, into the general risk class, which includes those fires that may occur practically anywhere within a forest unit.

For the purpose of rating the general hazard of given regions and forest types, only these general risks were considered. Rating of special risks will have to be done for each unit individually, according to the kind, extent, and location of of the fixed causes of fire within or adjacent to it, and according to the character of forest covering the particular parts of the unit exposed to such risks.

CHARACTER OF RATING

The rating of risks for different types within each of the 21 subregions was based on the following considerations:

1. No data are available to indicate what losses might amount to without any protection whatever. It has sometimes been stated that such data would afford a good measure for justifiable protection expenditure, but such is not the case. It is more important to know, and it is possible to learn, what losses may be expected with protection of different degrees of intensity.

2. Intensity of protection can be measured best by what may be termed the "hour control"—that is, the time within which fires on a given area are reached. The larger the personnel, or the better the facilities for detection, communication, and travel, the smaller will be the hour control. Reduction of hour control may be expected to result in reduced fire loss and also in reduced suppression cost, but will in general involve also increases in the cost of primary protection, which will partly offset the saving.

3. Data on primary protection costs for different types of forest and for protection of different degrees of intensity are not available nor can they be worked out on the basis of averages, but will vary according to the particular circumstances in each individual forest unit.

4. Such general rating as can be made, therefore, will attempt to show probable fire losses and the probable costs of fire suppression, per unit of area in different forest types of the several regions, with protection of various degrees of intensity. The balancing of these liabilities against costs of maintaining the corresponding degrees of protection will not be undertaken.

CALCULATION OF BASIC DATA FOR USE IN RATING

In the first place, the records of individual fires were segregated by subregions and as far as possible by types within these regions. This could not be done in all cases, because of the incompleteness of the data contained in the original records. Each group of these records was then studied along the following lines.

RELATION BETWEEN HOUR CONTROL AND SIZE OF FIRES

The areas burned per fire were correlated with the time elapsed before control work commenced. The purpose of this was to tie in the area burned with the intensity of protective organization. Area here means final area burned over by the fire up to the time it was extinguished; the time factor used is the elapsed period between discovery of the fire and the time when actual work of suppression began. Discovery time was used rather than the time when the fires started, because the latter was seldom reported. Fires which had obviously been burning for a long time before discovery were not included in the calculations, nor were fires that occurred under especially unfavorable conditions, as evidenced by abnormally slow spread. It is well known that fires usually spread very slowly, often hardly at all, during the night, and suppression crews usually can not get to a fire as fast at night as during the day. For these reasons, in order to put all the elapsed periods on approximately the same basis, the hours between 9 p. m. and 6 a. m. were rated at only half the actual elapsed time.

Fires were grouped according to elapsed periods—e. g., less than 1 hour, 1 to 2 hours, 2 to 3 hours, etc.; and the elapsed times and final acreages for the fires in each group were averaged and plotted as abscissae and ordinates,

respectively. Curves were then drawn on the basis of these points, showing the average size that fires may be expected to attain for different elapsed periods. (See figs. 4 to 18.)

RELATION BETWEEN SIZE OF FIRES AND COSTS OF SUPPRESSION

In organizing the suppression work, it is important to know the relation between the speed of attack, which is determined by the intensity of the protective organization, and the cost of putting out fires that may occur. The cost of suppression depends more directly on the size of the fire than on the speed of attack, though the latter has much to do with determining the size of fire. Accordingly, the fires were grouped by area classes—less than one acre, one to two acres, etc.—and the average areas and average suppression costs of fires within each group were then plotted on cross-section paper, as abscissae and ordinates, respectively. From the curves based on these points it is possible to determine the probable average suppression cost for fires of any given size, and from these curves and those of size based on elapsed time, the suppression cost according to speed of attack can be ascertained (Table VI and figs. 19 to 36).

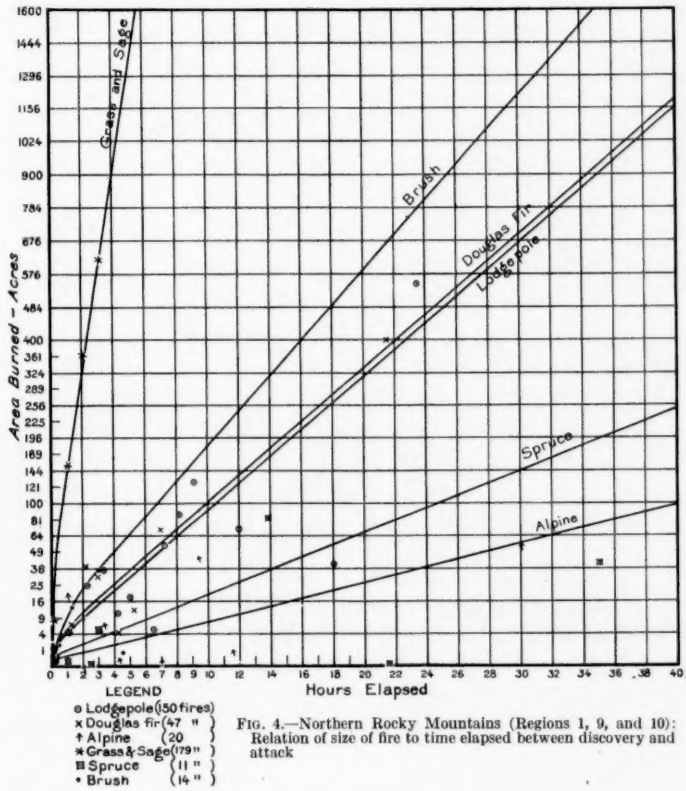

FIG. 4.—Northern Rocky Mountains (Regions 1, 9, and 10): Relation of size of fire to time elapsed between discovery and attack

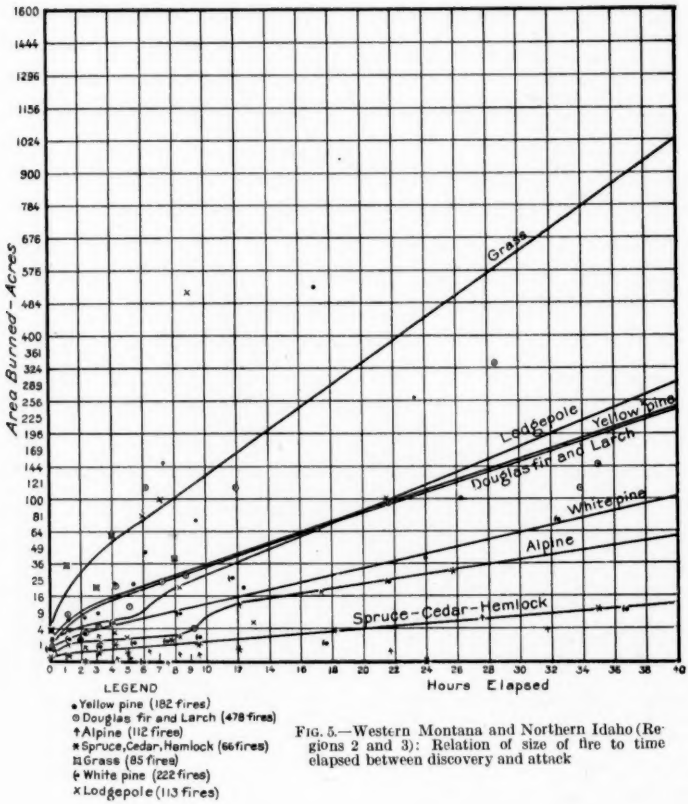

FIG. 5.—Western Montana and Northern Idaho (Regions 2 and 3): Relation of size of fire to time elapsed between discovery and attack

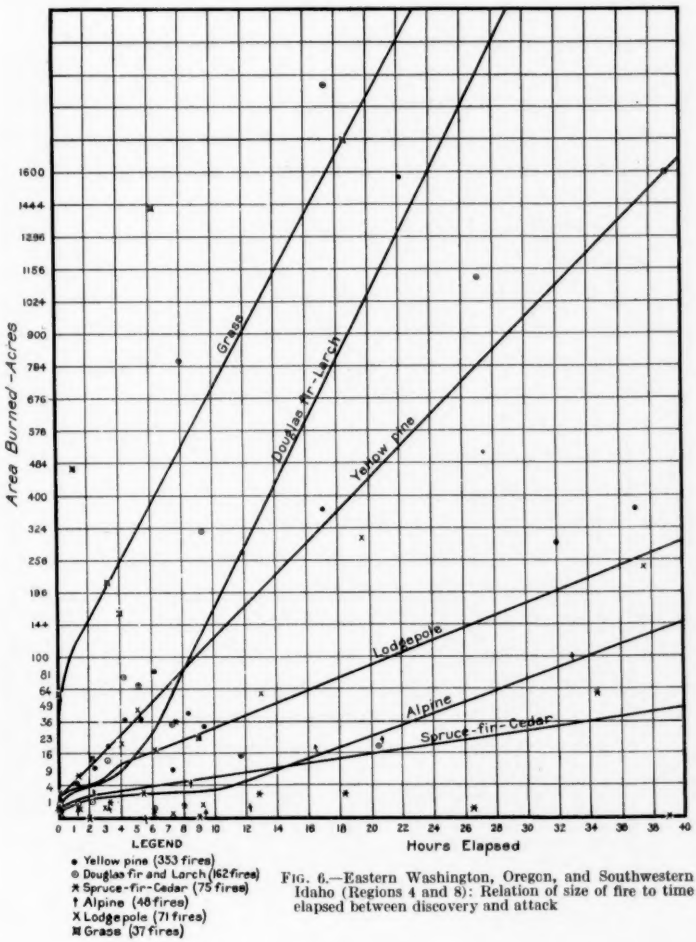

FIG. 6.—Eastern Washington, Oregon, and Southwestern Idaho (Regions 4 and 8): Relation of size of fire to time elapsed between discovery and attack

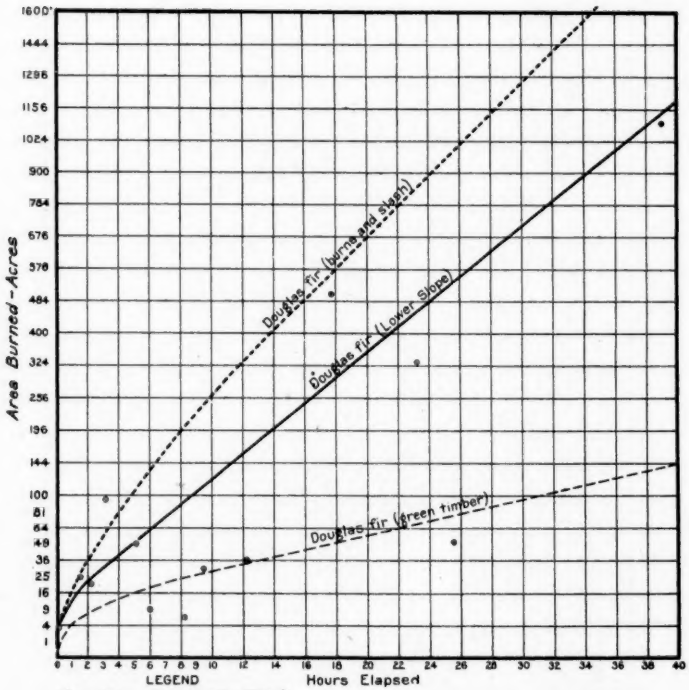

FIG. 7.—Western Washington and Oregon (Region 5): Relation of size of fire to time elapsed between discovery and attack

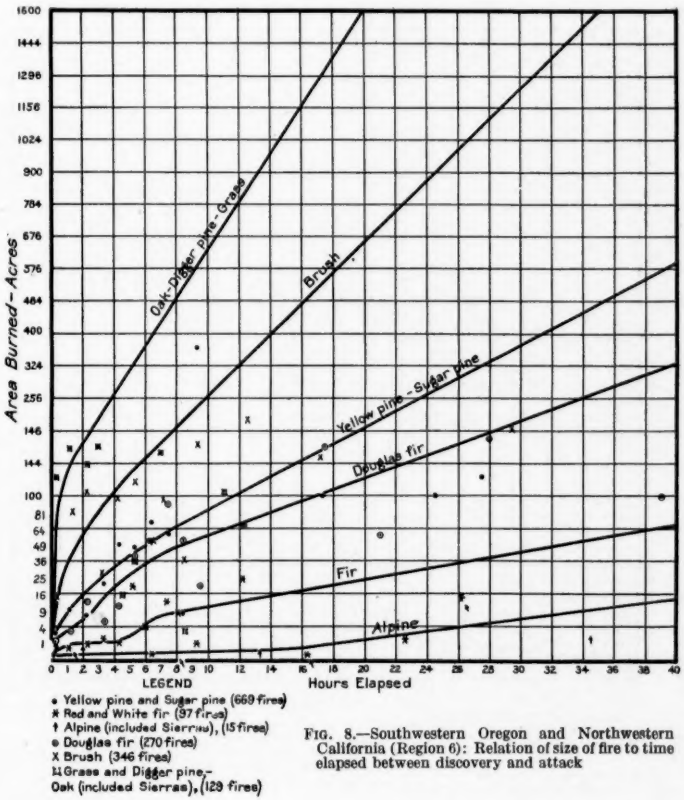

FIG. 8.—Southwestern Oregon and Northwestern California (Region 6): Relation of size of fire to time elapsed between discovery and attack

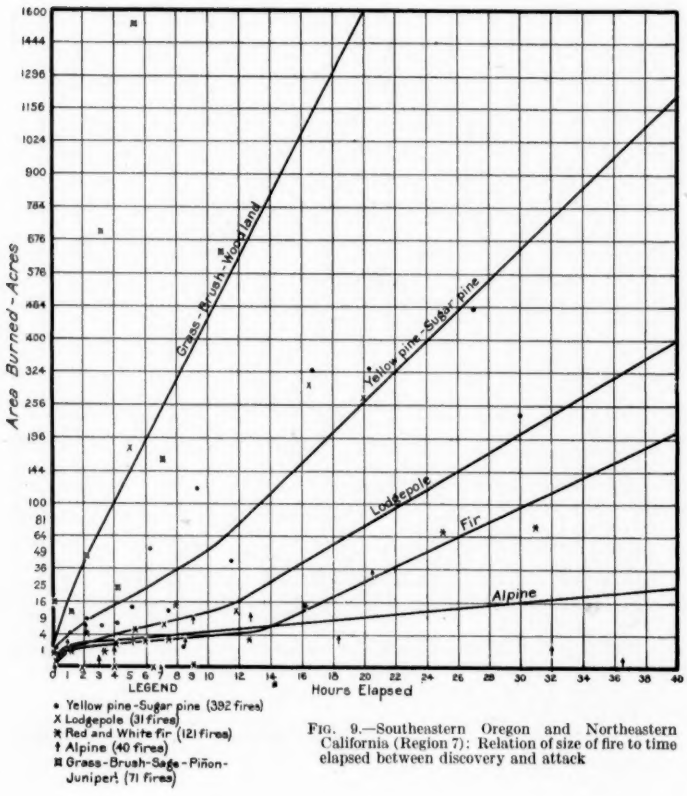

FIG. 9.—Southeastern Oregon and Northeastern California (Region 7): Relation of size of fire to time elapsed between discovery and attack

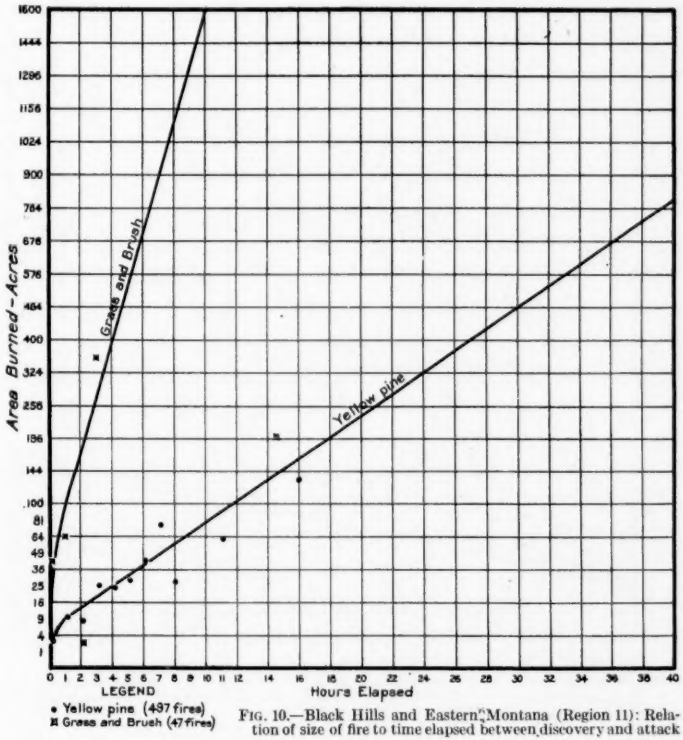

FIG. 10.—Black Hills and Eastern Montana (Region 11): Relation of size of fire to time elapsed between discovery and attack

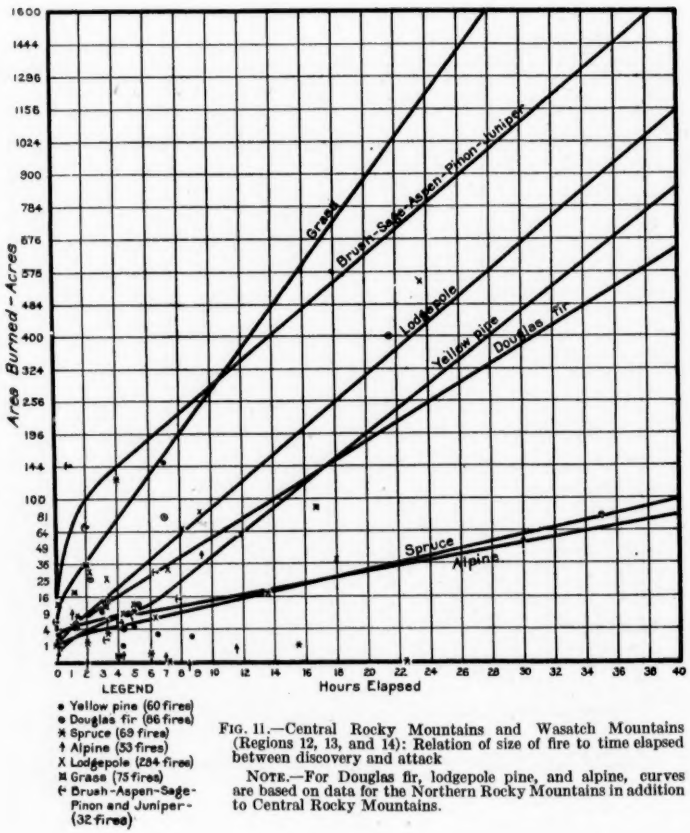

FIG. 11.—Central Rocky Mountains and Wasatch Mountains (Regions 12, 13, and 14): Relation of size of fire to time elapsed between discovery and attack

NOTE.—For Douglas fir, lodgepole pine, and alpine, curves are based on data for the Northern Rocky Mountains in addition to Central Rocky Mountains.

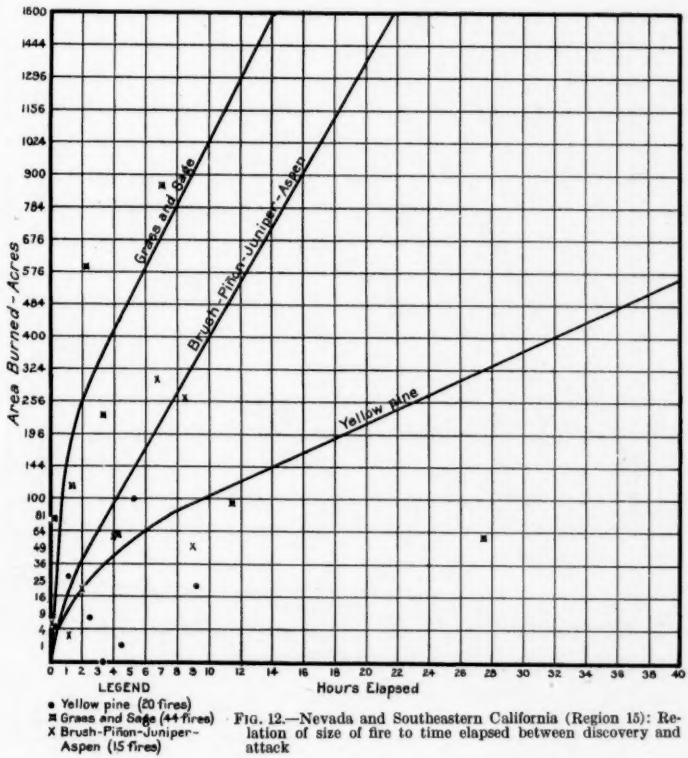

FIG. 12.—Nevada and Southeastern California (Region 15): Relation of size of fire to time elapsed between discovery and attack

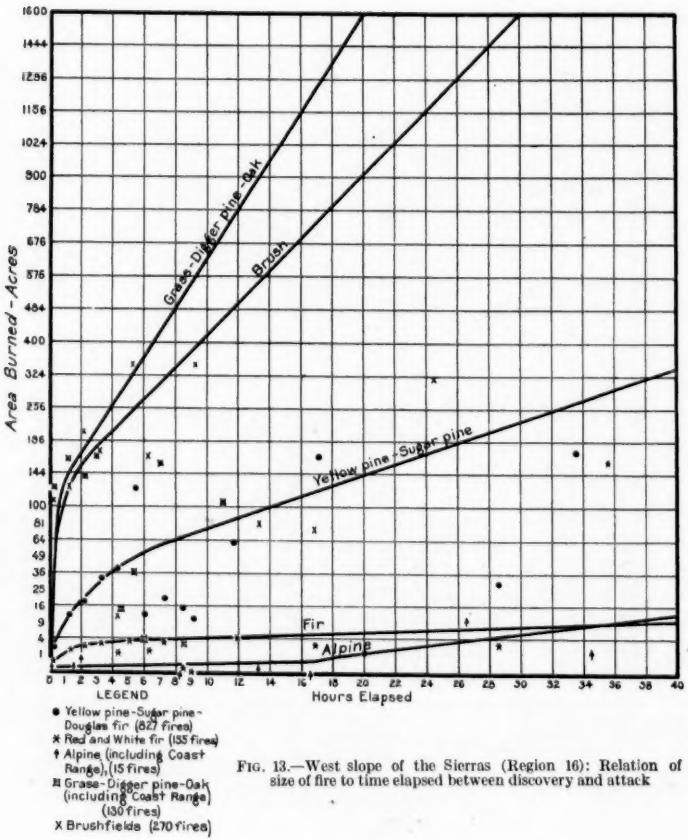

FIG. 13.—West slope of the Sierras (Region 16): Relation of size of fire to time elapsed between discovery and attack

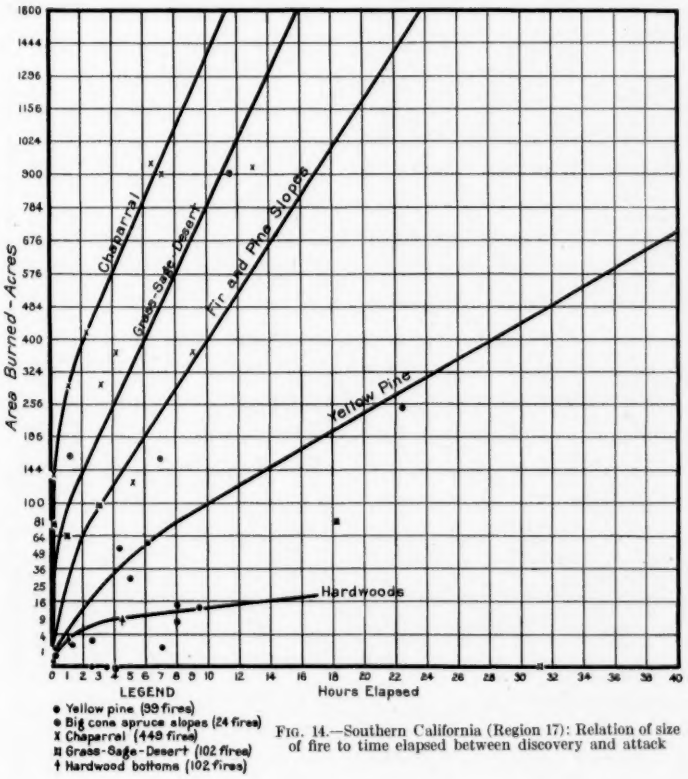

FIG. 14.—Southern California (Region 17): Relation of size of fire to time elapsed between discovery and attack

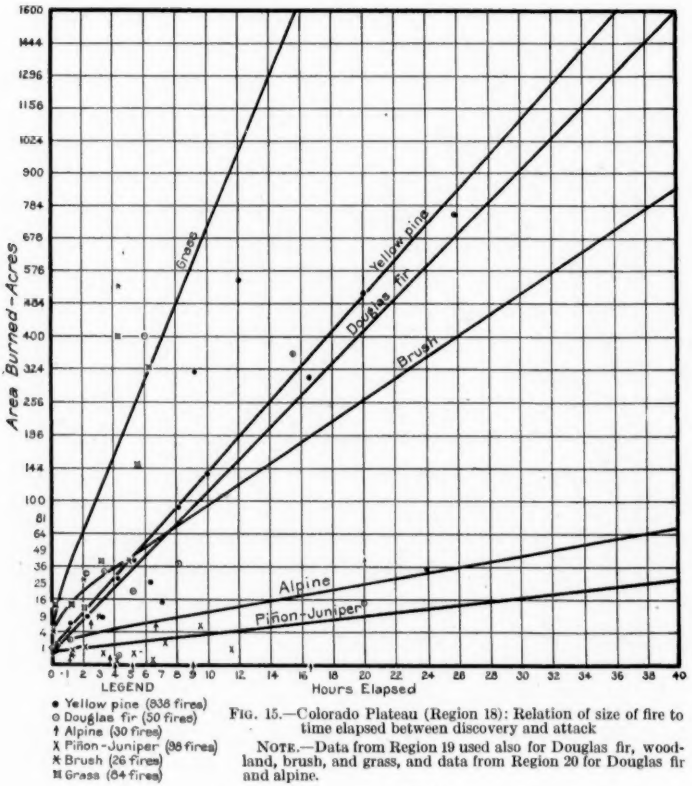

FIG. 15.—Colorado Plateau (Region 18): Relation of size of fire to time elapsed between discovery and attack

NOTE.—Data from Region 19 used also for Douglas fir, woodland, brush, and grass, and data from Region 20 for Douglas fir and alpine.

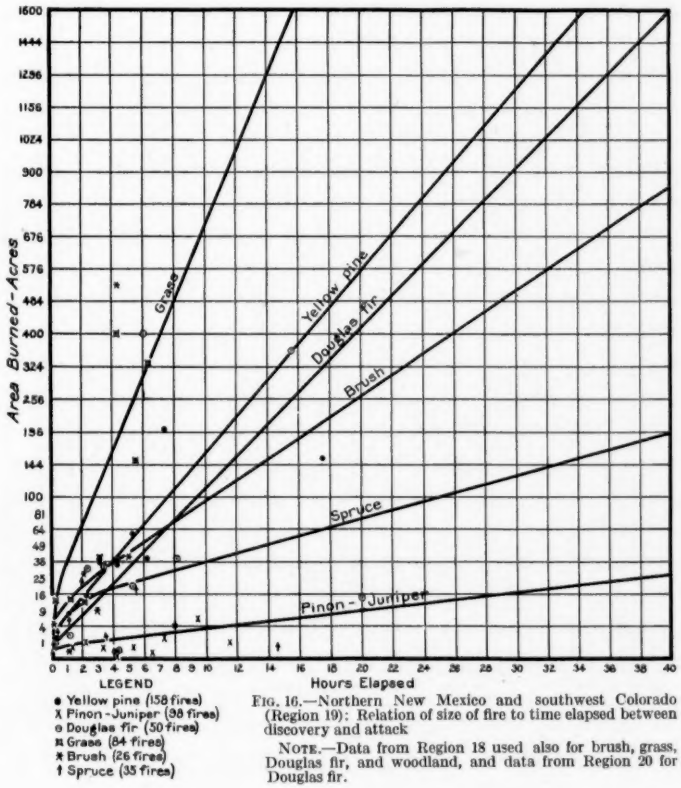

FIG. 16.—Northern New Mexico and southwest Colorado (Region 19): Relation of size of fire to time elapsed between discovery and attack

NOTE.—Data from Region 18 used also for brush, grass, Douglas fir, and woodland, and data from Region 20 for Douglas fir.

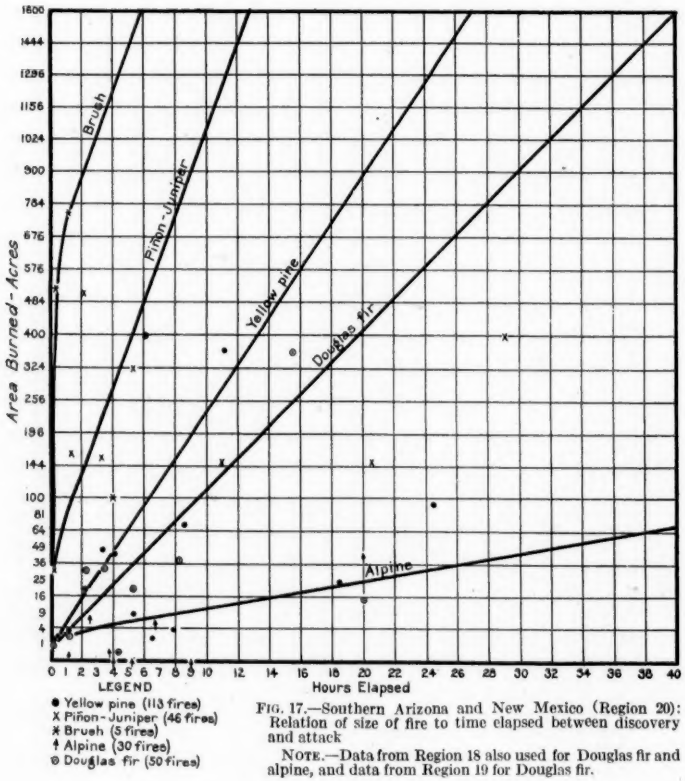

FIG. 17.—Southern Arizona and New Mexico (Region 20): Relation of size of fire to time elapsed between discovery and attack

NOTE.—Data from Region 18 also used for Douglas fir and alpine, and data from Region 19 for Douglas fir.

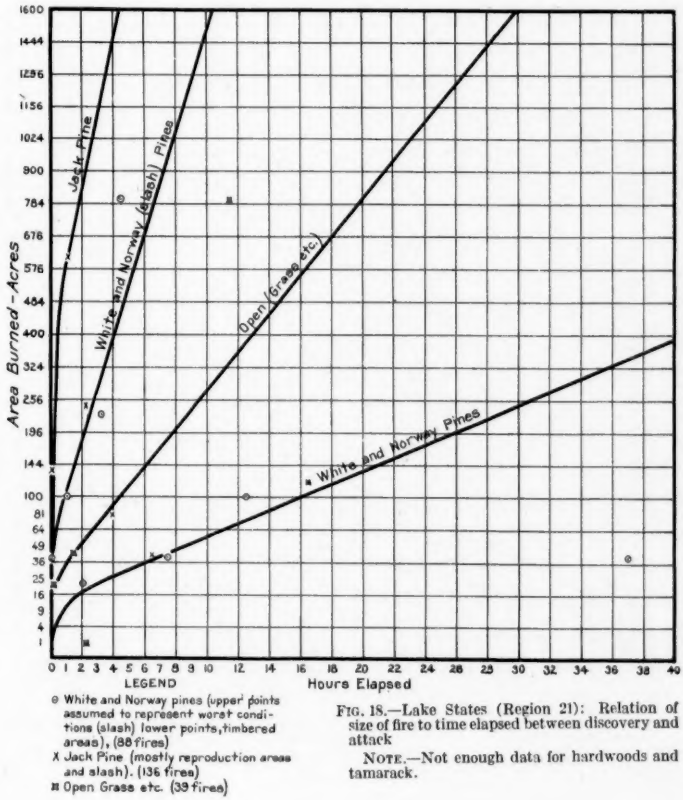

FIG. 18.—Lake States (Region 21): Relation of size of fire to time elapsed between discovery and attack

NOTE.—Not enough data for hardwoods and tamarack.

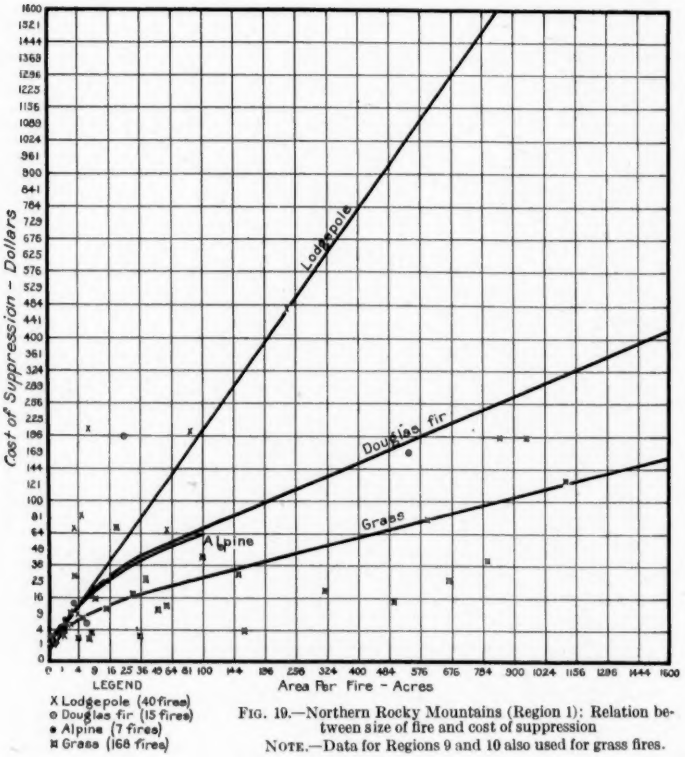

FIG. 19.—Northern Rocky Mountains (Region 1): Relation between size of fire and cost of suppression

NOTE.—Data for Regions 9 and 10 also used for grass fires.

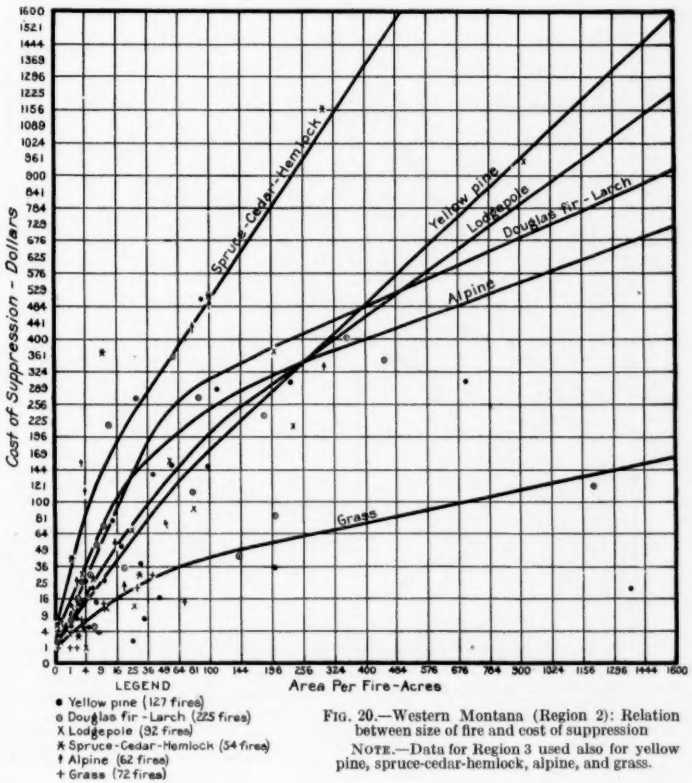

FIG. 20.—Western Montana (Region 2): Relation between size of fire and cost of suppression

NOTE.—Data for Region 3 used also for yellow pine, spruce-cedar-hemlock, alpine, and grass.

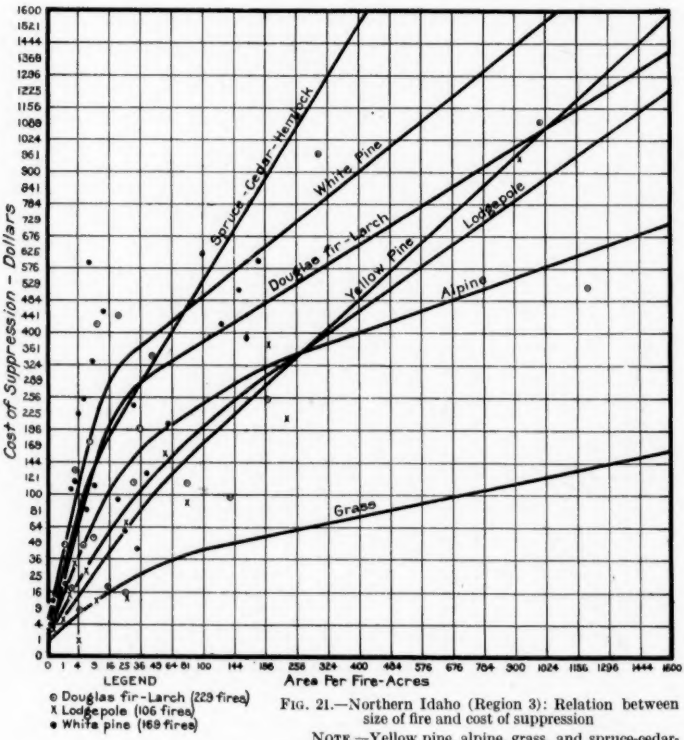

FIG. 21.—Northern Idaho (Region 3): Relation between size of fire and cost of suppression

NOTE.—Yellow pine, alpine, grass, and spruce-cedar-hemlock curves are identical with Western Montana curves. Lodgepole curve based chiefly on Western Montana data.

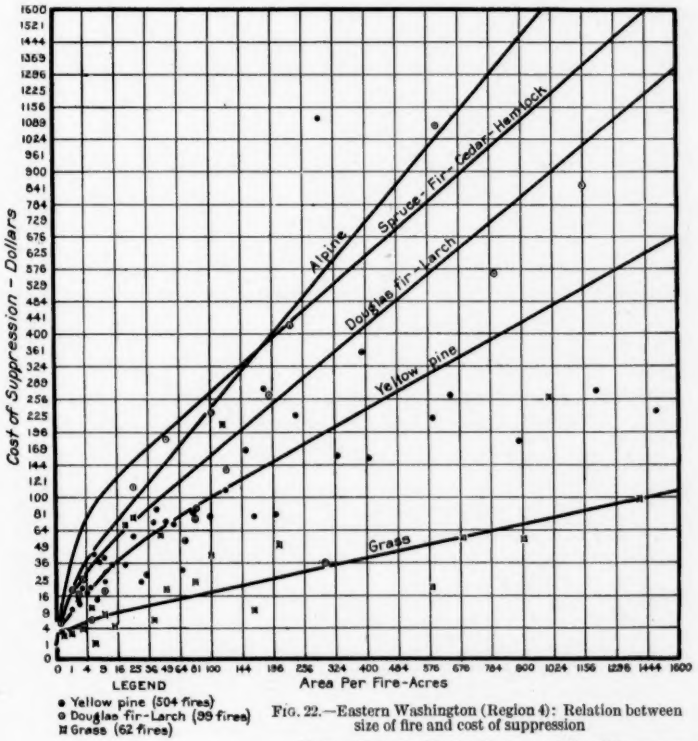

FIG. 22.—Eastern Washington (Region 4): Relation between size of fire and cost of suppression

NOTE.—Data for Region 8 also used for all types except Douglas fir-larch.

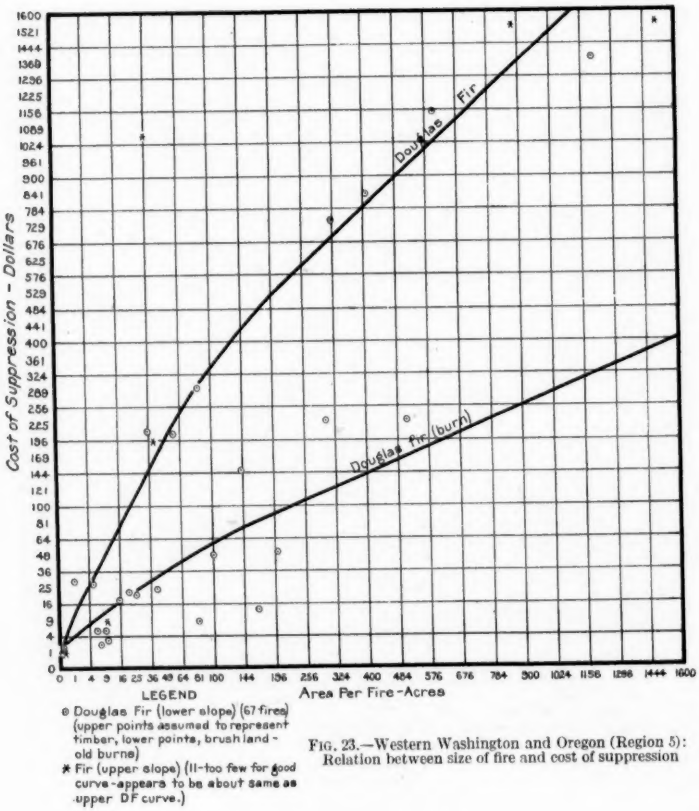

FIG. 23.—Western Washington and Oregon (Region 5): Relation between size of fire and cost of suppression

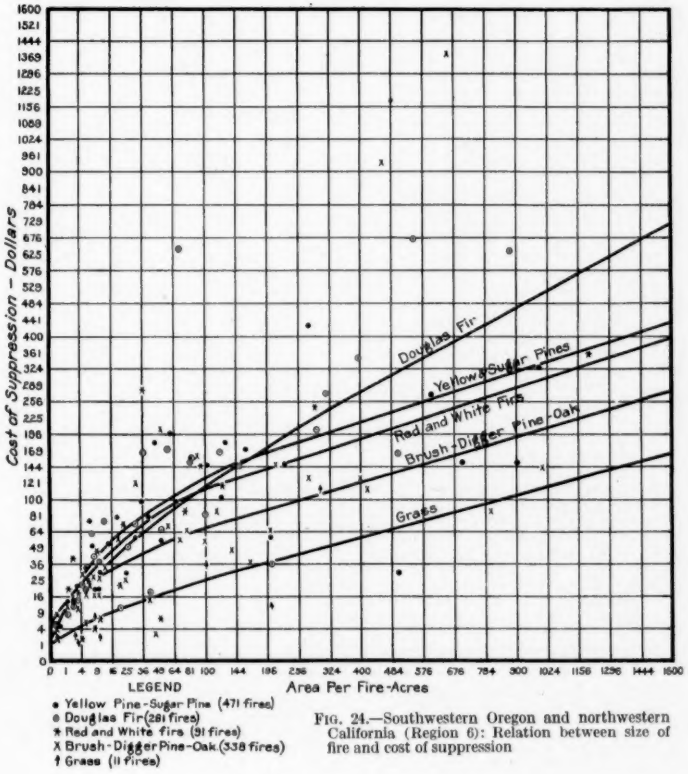

FIG. 24.—Southwestern Oregon and northwestern California (Region 6): Relation between size of fire and cost of suppression

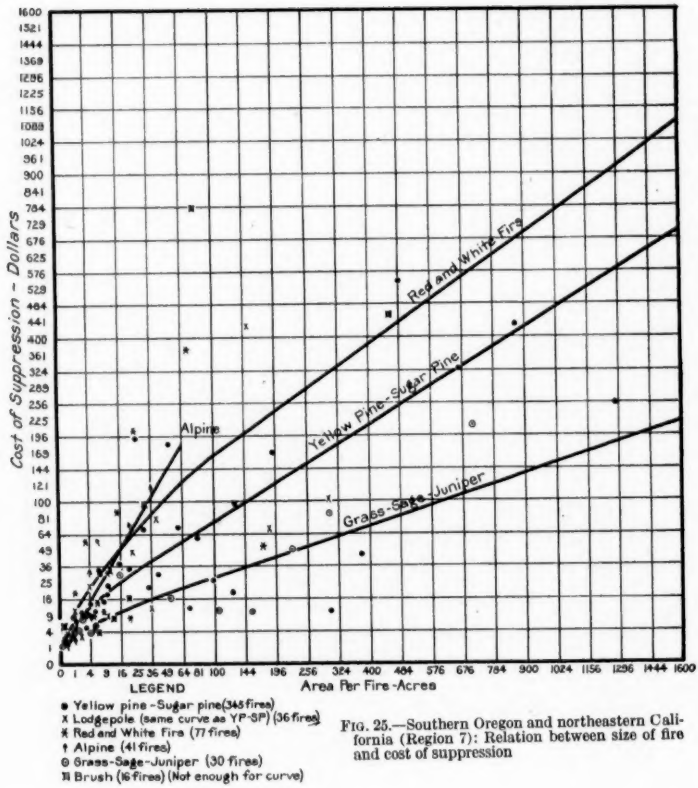

FIG. 25.—Southern Oregon and northeastern California (Region 7): Relation between size of fire and cost of suppression

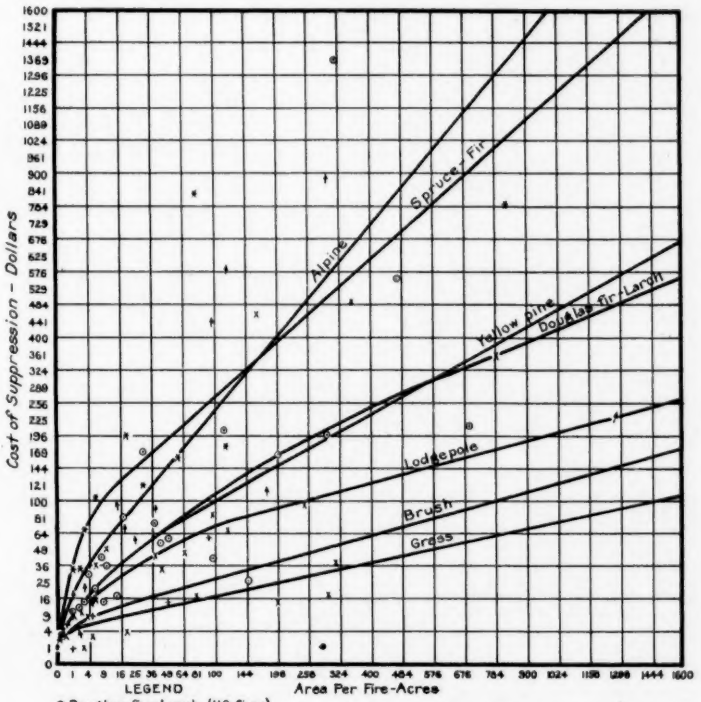

FIG. 26.—Eastern Oregon and southwestern Idaho (Region 8): Relation between size of fire and cost of suppression

NOTE.—Curves for all types except brush and Douglas fir-larch are identical with those for Region 4.

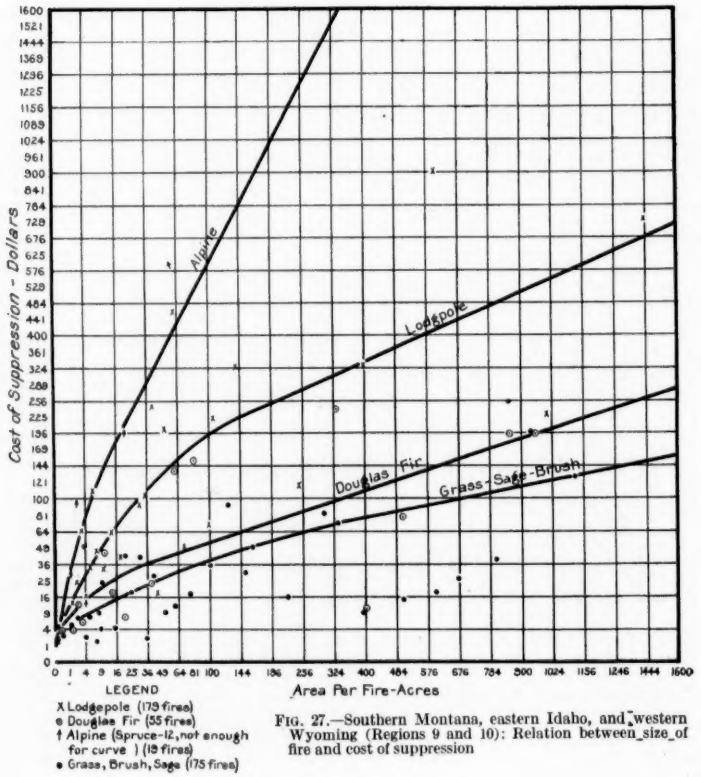

FIG. 27.—Southern Montana, eastern Idaho, and western Wyoming (Regions 9 and 10): Relation between size of fire and cost of suppression

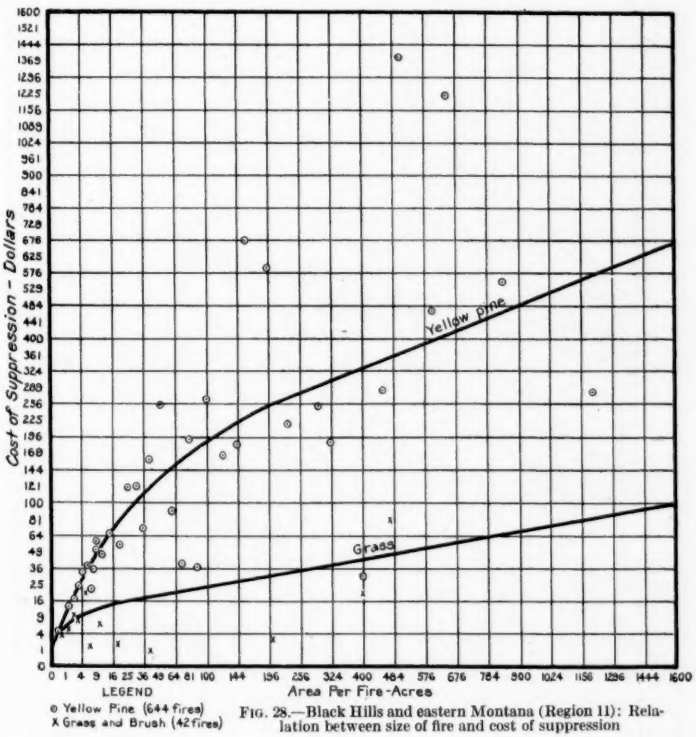

FIG. 28.—Black Hills and eastern Montana (Region 11): Relation between size of fire and cost of suppression

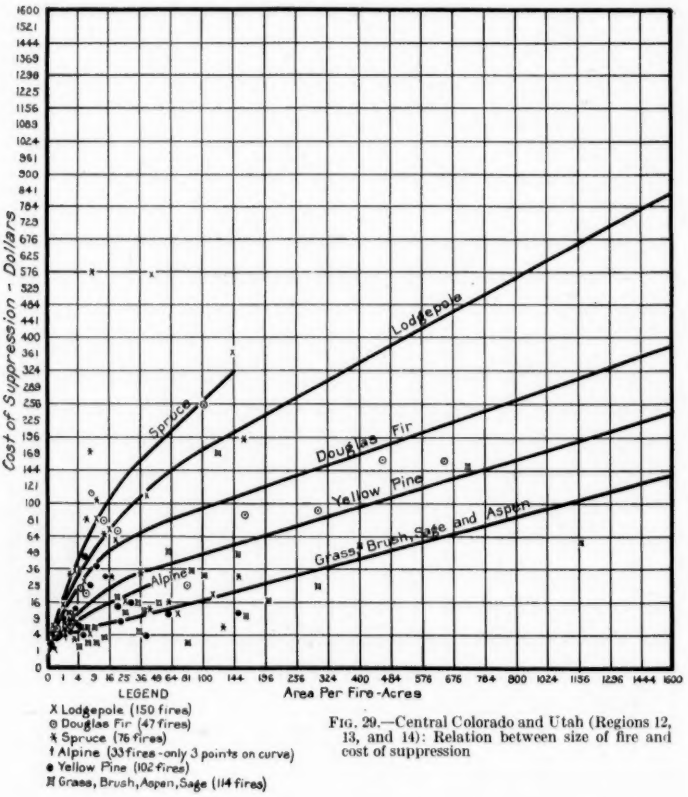

FIG. 29.—Central Colorado and Utah (Regions 12, 13, and 14): Relation between size of fire and cost of suppression

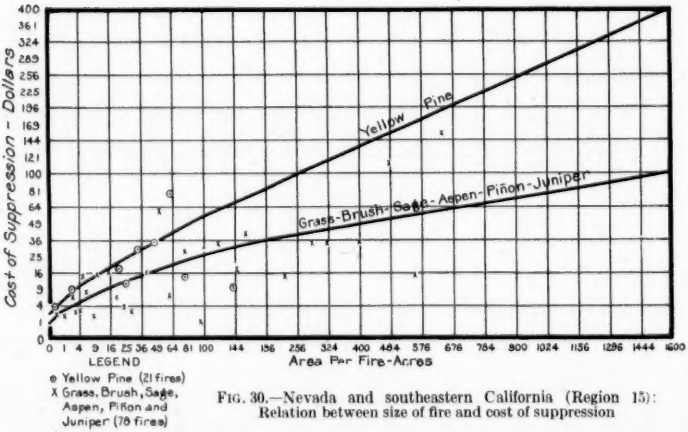

FIG. 30.—Nevada and southeastern California (Region 15): Relation between size of fire and cost of suppression

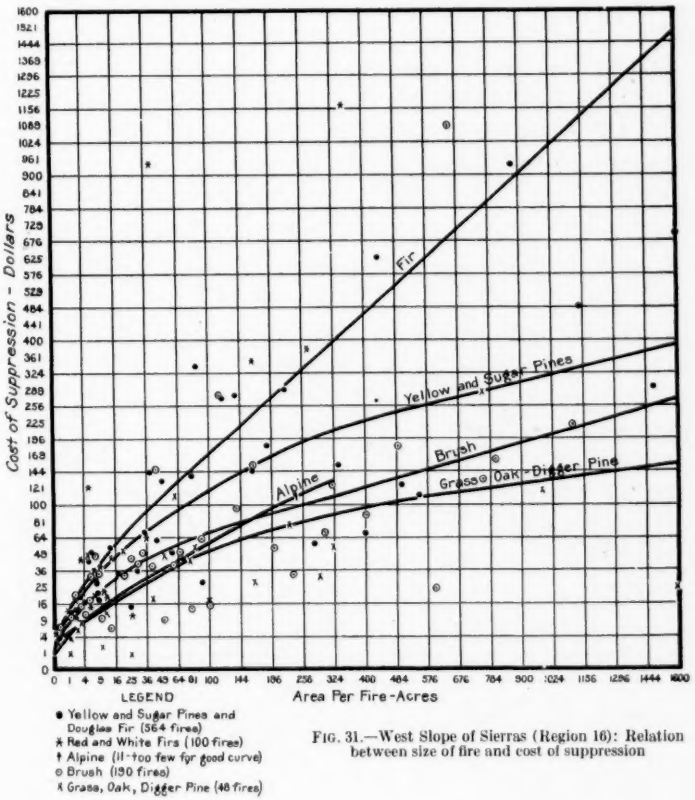
Cost of Suppression - Dollars
Area Per Fire-Acres
Fir
Yellow and Sugar Pines
Brush
Alpine
Grass & Oak-Digger Pine
LEGEND
● Yellow and Sugar Pines and Douglas Fir (564 fires)
✱ Red and White Firs (100 fires)
† Alpine (11-too few for good curve)
⊙ Brush (190 fires)
x Grass, Oak, Digger Pine (48 fires)

FIG. 31.—West Slope of Sierras (Region 16): Relation between size of fire and cost of suppression

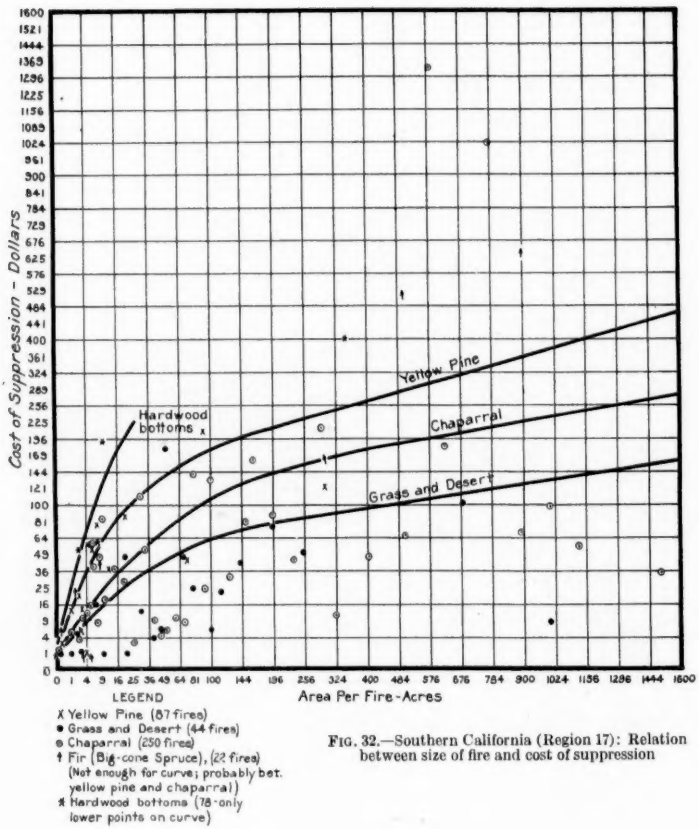

FIG. 32.—Southern California (Region 17): Relation between size of fire and cost of suppression

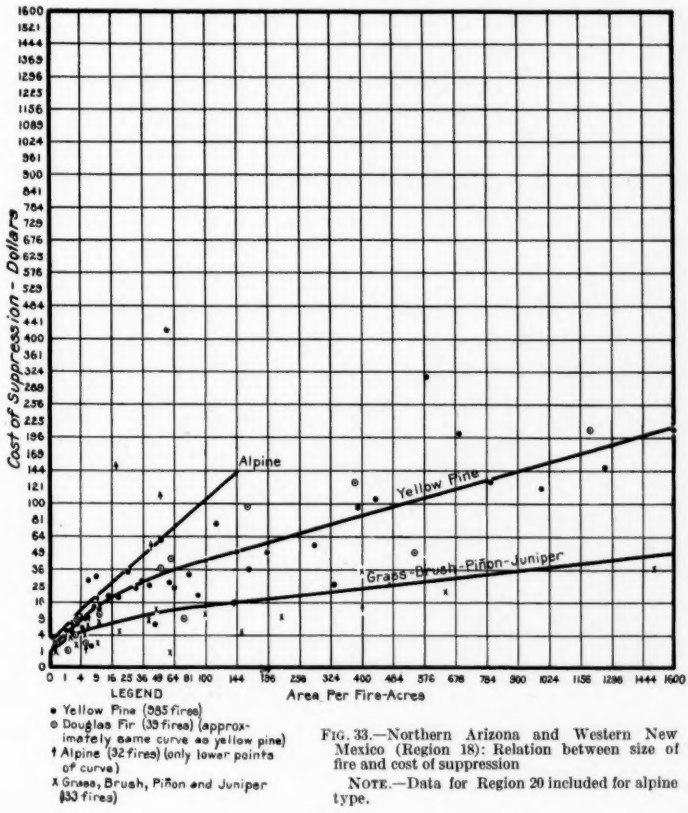

FIG. 33.—Northern Arizona and Western New Mexico (Region 18): Relation between size of fire and cost of suppression

NOTE.—Data for Region 20 included for alpine type.

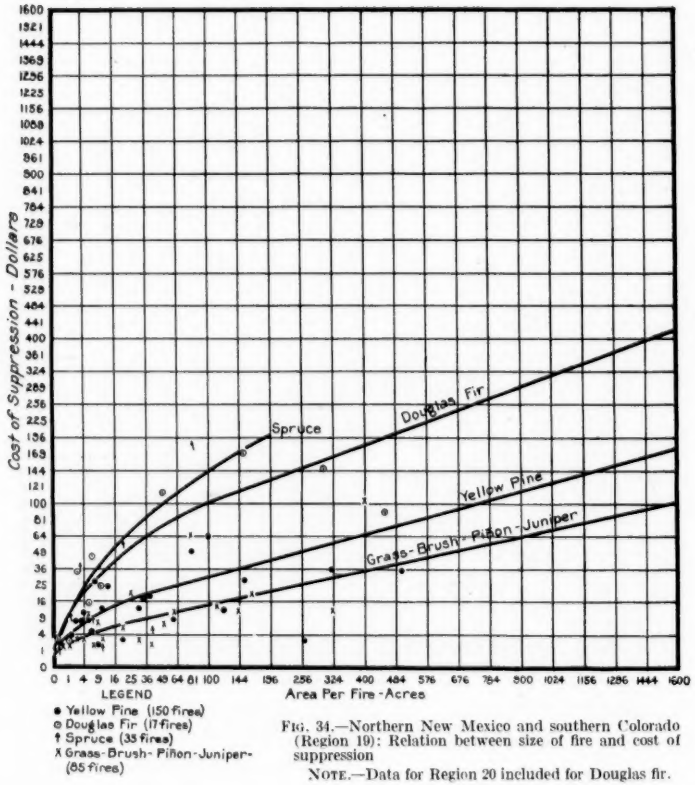

FIG. 34.—Northern New Mexico and southern Colorado (Region 19): Relation between size of fire and cost of suppression

NOTE.—Data for Region 20 included for Douglas fir.

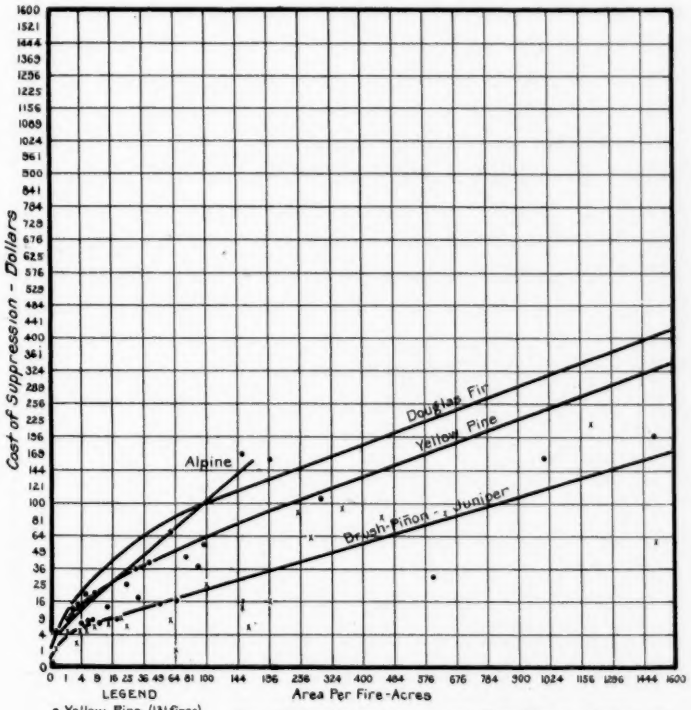

FIG. 35.—Southern Arizona and New Mexico (Region 20): Relation between size of fire and cost of suppression

NOTE.—Curve for Douglas fir identical with that for Region 19; alpine curve same as that for Region 18.

19978—25†——4

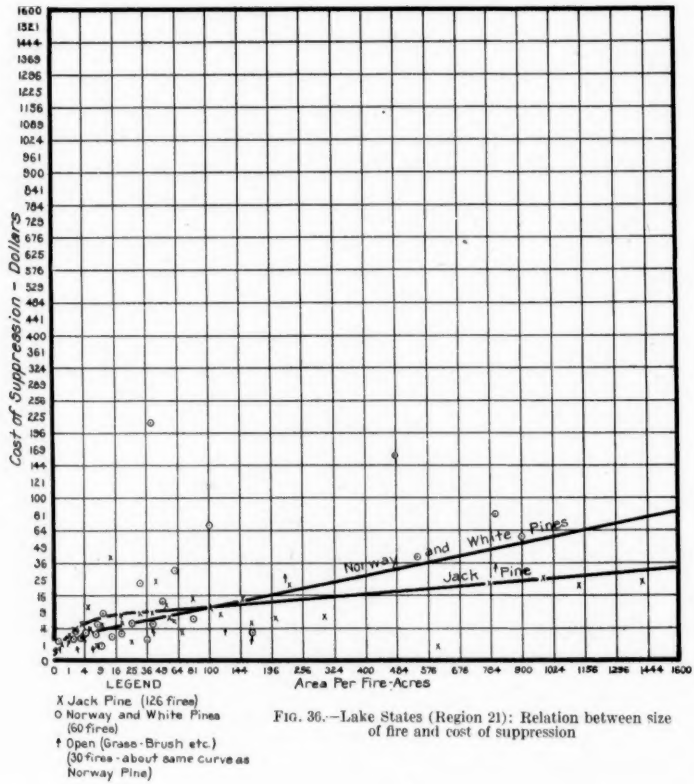

FIG. 36.—Lake States (Region 21): Relation between size of fire and cost of suppression

TABLE VI.—*Average costs of suppressing fires, according to time elapsed between detection and start of suppression work* [a]

REGION 2—WESTERN MONTANA, 1911–1915

Time elapsed (hours)	Forest types						
	Western yellow pine	Douglas fir and larch	Western white pine	Lodgepole pine	Spruce, hemlock, white fir	Subalpine	Open
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	11.00	15.00	42.00	10.00	12.00	11.00	12.00
1	16.00	25.00	69.00	14.00	14.00	15.00	17.00
2	27.00	48.00	92.00	19.00	17.00	19.00	24.00
3	34.00	72.00	110.00	24.00	19.00	21.00	29.00
4	40.00	88.00	130.00	26.00	21.00	22.00	33.00
5	46.00	102.00	155.00	28.00	24.00	24.00	36.00
6	52.00	115.00	175.00	35.00	26.00	26.00	39.00
7	58.00	130.00	200.00	50.00	29.00	27.00	42.00
8	64.00	145.00	230.00	62.00	32.00	29.00	45.00
9	72.00	165.00	250.00	72.00	36.00	35.00	46.00
10	80.00	185.00	270.00	81.00	40.00	58.00	49.00
12	96.00	215.00	295.00	100.00	49.00	88.00	52.00
15	120.00	255.00	325.00	130.00	59.00	110.00	59.00
20	155.00	290.00	360.00	185.00	81.00	135.00	71.00

REGION 3—NORTHERN IDAHO

Time elapsed (hours)	Forest types						
	Western yellow pine	Douglas fir and larch	Western white pine	Lodgepole pine	Spruce, fir, cedar, hemlock	Subalpine	Open
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	11.00	42.00	42.00	13.00	12.00	11.00	12.00
1	16.00	74.00	69.00	17.00	14.00	15.00	17.00
2	27.00	135.00	92.00	23.00	17.00	19.00	24.00
3	34.00	180.00	110.00	28.00	19.00	21.00	29.00
4	40.00	200.00	130.00	30.00	21.00	22.00	33.00
5	46.00	220.00	155.00	33.00	24.00	24.00	36.00
6	52.00	235.00	175.00	40.00	26.00	26.00	39.00
7	58.00	245.00	200.00	58.00	29.00	27.00	42.00
8	64.00	260.00	230.00	72.00	32.00	29.00	45.00
9	72.00	270.00	250.00	81.00	36.00	35.00	46.00
10	80.00	280.00	270.00	88.00	40.00	58.00	49.00
12	96.00	300.00	295.00	110.00	49.00	88.00	52.00
15	120.00	325.00	325.00	135.00	59.00	110.00	59.00
20	155.00	360.00	360.00	185.00	81.00	135.00	71.00

[a] Tables prepared for Regions 1, 5, 7, 9, 10, 11, 15, 18, and 20 are omitted because of the rather inadequate data on which they are based.

TABLE VI.—*Average costs of suppressing fires, according to time elapsed between detection and start of suppression work*—Continued

REGION 4—EASTERN WASHINGTON

Time elapsed (hours)	Forest types					
	Western yellow pine	Douglas fir and larch	Lodgepole pine	Spruce, cedar, white fir, hemlock	Subalpine	Open
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	15.00	19.00	13.00	25.00	11.00	16.00
1	20.00	25.00	14.00	36.00	15.00	19.00
2	29.00	30.00	15.00	48.00	20.00	22.00
3	38.00	36.00	18.00	55.00	25.00	26.00
4	49.00	44.00	24.00	64.00	26.00	29.00
5	59.00	58.00	27.00	68.00	27.00	33.00
6	69.00	76.00	30.00	73.00	28.00	37.00
7	79.00	105.00	33.00	78.00	29.00	42.00
8	90.00	135.00	35.00	83.00	30.00	48.00
9	100.00	180.00	37.00	88.00	31.00	53.00
10	115.00	220.00	41.00	94.00	32.00	58.00
12	135.00	325.00	46.00	100.00	42.00	72.00
15	175.00	510.00	54.00	110.00	62.00	92.00
20	250.00	925.00	69.00	125.00	98.00	130.00

REGION 6—SOUTHERN OREGON AND NORTHERN CALIFORNIA COAST RANGES

Time elapsed (hours)	Forest types						
	Western yellow and sugar pine	Douglas fir	Red and white fir	Subalpine [a]	Digger pine–oak	Brush	Grass
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	27.00	12.00	12.00	8.00	66.00	35.00	24.00
1	40.00	15.00	13.00	8.25	76.00	44.00	30.00
2	56.00	20.00	14.00	8.50	85.00	53.00	35.00
3	67.00	34.00	16.00	8.75	92.00	64.00	40.00
4	78.00	44.00	17.00	9.00	100.00	70.00	45.00
5	86.00	53.00	19.00	9.25	108.00	76.00	50.00
6	94.00	61.00	24.00	9.50	117.00	81.00	56.00
7	100.00	67.00	31.00	9.75	128.00	85.00	62.00
8	108.00	73.00	35.00	10.00	135.00	90.00	67.00
9	115.00	77.00	38.00	10.50	145.00	96.00	74.00
10	120.00	83.00	40.00	11.00	155.00	100.00	81.00
12	130.00	92.00	44.00	11.50	175.00	110.00	96.00
15	145.00	110.00	48.00	12.00	210.00	130.00	120.00
20	170.00	130.00	60.00	16.00	280.00	160.00	165.00

[a] Costs for subalpine are based on red fir curve.

TABLE VI.—*Average costs of suppressing fires, according to time elapsed between detection and start of suppression work*—Continued

REGION 8—EASTERN OREGON AND SOUTHWESTERN IDAHO

Time elapsed (hours)	Forest types						
	Western yellow pine	Douglas fir and larch	Lodgepole pine	Spruce and fir	Subalpine	Brush	Grass and sage
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	15.00	10.00	13.00	25.00	11.00	24.00	16.00
1	20.00	14.00	14.00	26.00	15.00	29.00	19.00
2	29.00	18.00	15.00	48.00	20.00	34.00	22.00
3	38.00	22.00	18.00	55.00	25.00	40.00	26.00
4	49.00	28.00	24.00	64.00	26.00	46.00	29.00
5	59.00	37.00	27.00	68.00	27.00	53.00	33.00
6	69.00	49.00	30.00	73.00	28.00	61.00	37.00
7	79.00	70.00	33.00	78.00	29.00	67.00	42.00
8	90.00	100.00	35.00	83.00	30.00	76.00	48.00
9	100.00	120.00	37.00	88.00	31.00	85.00	53.00
10	115.00	145.00	41.00	94.00	32.00	95.00	58.00
12	135.00	200.00	46.00	100.00	42.00	115.00	72.00
15	175.00	285.00	54.00	110.00	62.00	145.00	92.00
20	250.00	430.00	69.00	125.00	98.00	210.00	130.00

REGION 12—EASTERN COLORADO; REGION 13—NORTHWESTERN COLORADO AND SOUTHERN WYOMING; REGION 14—WASATCH AND UINTA RANGES (UTAH)[a]

Time elapsed (hours)	Forest types						
	Western yellow pine	Douglas fir	Lodgepole pine	Engelmann spruce	Subalpine	Woodland and aspen brush	Grass and sage
	Dolls.	*Dolls.*	*Dolls.*	*Dolls*	*Dolls.*	*Dolls.*	*Dolls.*
½	9.00	19.00	20.00	22.00	4.00	10.00	7.00
1	11.00	24.00	30.00	28.00	6.00	14.00	8.50
2	13.00	36.00	50.00	36.00	8.00	18.00	10.00
3	15.00	45.00	66.00	45.00	11.00	20.00	13.00
4	16.00	50.00	83.00	50.00	11.50	22.00	15.00
5	18.00	56.00	100.00	56.00	12.00	24.00	18.00
6	20.00	61.00	115.00	62.00	13.00	26.00	20.00
7	24.00	66.00	130.00	69.00	14.00	28.00	24.00
8	28.00	71.00	145.00	74.00	14.50	30.00	26.00
9	32.00	75.00	160.00	81.00	15.00	32.00	30.00
10	35.00	80.00	170.00	90.00	15.50	35.00	34.00
12	41.00	85.00	195.00	100.00	16.00	40.00	42.00
15	50.00	100.00	230.00	120.00	18.00	49.00	56.00
20	67.00	120.00	300.00	150.00	21.00	64.00	83.00

[a] These three regions combined in order to afford better basis for curves. They are fairly similar.

TABLE VI.—*Average costs of suppressing fires, according to time elapsed between detection and start of suppression work*—Continued

REGION 16—WEST SLOPE OF SIERRAS

Time elapsed (hours)	Forest types					
	Western yellow and sugar pines and Douglas fir	Red and white firs	Subalpine	Lodgepole[a] and knobcone pines	Digger pine–oak and grass	Brushfields
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	23.00	10.00	1.00	23.00	53.00	60.00
1	36.00	15.00	1.50	36.00	61.00	72.00
2	52.00	21.00	1.75	52.00	68.00	81.00
3	64.00	22.00	2.00	64.00	74.00	88.00
4	72.00	23.00	2.00	72.00	81.00	94.00
5	81.00	24.00	2.00	81.00	87.00	99.00
6	86.00	25.00	2.00	86.00	93.00	104.00
7	90.00	26.00	2.00	90.00	98.00	109.00
8	94.00	26.50	2.00	94.00	104.00	115.00
9	100.00	27.00	2.25	100.00	108.00	120.00
10	105.00	28.00	2.50	105.00	112.00	125.00
12	110.00	29.50	3.00	110.00	120.00	140.00
15	120.00	31.00	3.50	120.00	130.00	155.00
20	145.00	34.00	6.00	145.00	155.00	190.00

[a] Because of insufficient data for lodgepole type, figures for the yellow pine, sugar pine, and incense cedar type were used.

REGION 17—SOUTHERN CALIFORNIA

Time elapsed (hours)	Forest types					
	Western yellow and Jeffrey pine	Fir[a] and pine slopes	Subalpine[b]	Chaparral	Hardwood bottoms	Grass and sage
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	28.00	24.00	1.00	145.00	32.00	50.00
1	45.00	45.00	1.50	160.00	55.00	62.00
2	77.00	79.00	1.75	175.00	87.00	70.00
3	102.00	100.00	2.00	190.00	110.00	77.00
4	119.00	115.00	2.00	200.00	125.00	85.00
5	132.00	130.00	2.00	210.00	135.00	90.00
6	145.00	140.00	2.00	220.00	140.00	95.00
7	155.00	150.00	2.00	230.00	145.00	100.00
8	165.00	160.00	2.00	240.00	150.00	105.00
9	170.00	170.00	2.25	250.00	155.00	110.00
10	180.00	180.00	2.50	260.00	165.00	120.00
12	190.00	190.00	3.00	280.00	175.00	130.00
15	200.00	210.00	3.50	315.00	190.00	150.00
20	230.00	245.00	6.00	380.00	215.00	190.00

[a] Based on area from fir slope curve, and costs from chaparral curve.

[b] Based on figures for Region 16 (Sierras).

TABLE VI.—*Average costs of suppressing fires, according to time elapsed between detection and start of suppression work*—Continued

REGION 19—SOUTHWESTERN COLORADO AND NORTHERN NEW MEXICO

Time elapsed (hours)	Forest types						
	Western yellow pine	Douglas fir mixed	Spruce and subalpine	Lodgepole pine [a]	Pinon-juniper	Brush	Grass
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
½	7.50	13.00	25.00	20.00	1.75	5.00	7.00
1	9.50	18.00	34.00	30.00	2.00	6.00	9.00
2	14.00	28.00	47.00	50.00	2.15	7.00	12.00
3	17.00	40.00	53.00	66.00	2.30	8.00	16.00
4	20.00	50.00	59.00	83.00	2.45	9.00	20.00
5	23.00	61.00	65.00	100.00	2.60	10.00	25.00
6	26.00	72.00	69.00	115.00	2.80	11.00	30.00
7	29.00	81.00	72.00	130.00	3.00	12.00	35.00
8	32.50	90.00	77.00	145.00	3.25	13.00	41.00
9	36.00	99.00	81.00	160.00	3.50	14.00	46.00
10	39.50	106.00	85.00	170.00	3.75	15.00	54.00
12	47.00	120.00	94.00	195.00	4.00	17.00	67.00
15	59.00	145.00	104.00	230.00	4.25	20.00	94.00
20	83.00	190.00	123.00	300.00	5.00	27.00	145.00

[a] For lodgepole pine, figures for Region 13 were used.

REGION 21—LAKE STATES

Time elapsed (hours)	Forest types				
	Eastern white and red pine (green)	White and red pine (slash, etc.)	Jack pine (mostly slash)	Other timber (green) [a]	Open
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
½	3.00	9.50	18.00	3.00	5.00
1	4.00	11.50	21.00	4.00	6.00
2	4.50	16.00	23.00	4.50	7.00
3	5.00	21.00	27.00	5.00	9.00
4	5.50	27.00	31.00	5.50	10.00
5	6.00	34.00	35.00	6.00	11.50
6	6.25	41.50	39.00	6.25	13.50
7	6.75	49.00	44.00	6.75	15.00
8	7.25	58.00	48.00	7.25	17.00
9	7.75	69.00	51.00	7.75	18.50
10	8.00	79.00	55.00	8.00	21.00
12	9.00	100.00	66.00	9.00	25.00
15	10.50	145.00	83.00	10.50	32.50
20	13.00	235.00	115.00	13.00	47.00

[a] Because of insufficient data for fires in other timber types (spruce, balsam, tamarack, hardwoods), the same figures were used as for white and Norway pine green.

AMOUNT OF DAMAGE DONE BY FIRES

Damage varies directly with area burned, and therefore may be expressed on an acre basis. The question of damage is the most difficult part of the whole problem, for several reasons. In the first place, no satisfactory method has yet been devised for putting money value on the less tangible elements of value present in a forest. Even the value of merchantable timber can be determined with a reasonable degree of accuracy only where such timber is so located as to be immediately saleable, and the value of the same timber varies more or less from year to year. In case of young growth, a number of complications enter which make it almost impossible to value it on a scientific basis, or rather, to determine the monetary loss in case of its destruction or injury by fire. The fire reports, in the majority of cases, entirely neglect to evaluate the damage to young growth, or estimate it so crudely and inconsistently that the figures are worthless. Damage to forage is ignored, not only because of the extreme paucity of data, but also because the existing data indicate that such damage is less than the probable error in estimating damage to timber. In studying the records of individual fires, then, it was decided to ignore the estimates of damage expressed in dollars, and to consider only the data as to quantity of damage expressed in board feet of timber and acres of reproduction. The fire records are particularly incomplete on these points, especially in regard to reproduction destroyed, but they represent all the information that can be readily obtained. For those fires within each type and subregion for which data were available regarding amount of damage, the average damage per acre burned over was ascertained. The figures given in Table VII are in each case averages for all burns in the given types, regardless of age class or density of stand, so should not be taken as indication of the amount of damage in mature well-stocked stands. For this reason the average amount of damage given for the mixed pine type of the Sierras, for instance, is less than the amount indicated by studies made in mature stands. It is important to know the relation between the quantities of timber and young growth present on the burned area before the fire and the amount destroyed—in other words, what the ratio of destruction is. Data on this point are even more fragmentary than those on the total amount of damage, but such as are available were compiled.

TABLE VII.—*Average amount of damage done by fires in different types and regions, 1911–1915*[a]

Type	Region	Timber destroyed		Young growth killed	
		Amount per acre	Percentage of stand	Percentage of burned area	Percentage of original stand
		Bd. ft.			
Yellow pine, including western yellow pine, sugar pine, incense cedar, and white fir mixture of California.	2, 3	695	14. 9	56	83
	4	420	14. 8	48	77
	6	860	12. 4	46	63
	7	820	7. 0	36	66
	8	950	8. 4	70	93
	11	500	40. 0	20	68
	12, 14	290	39. 6	21	48
	15	385	8. 3	44	88
	16	630	7. 6	27	50
	17	560	6. 7	44	58
	18, 19	100	4. 4	26	47
	20	200	18. 6	52	77
Douglas fir, including western larch and other mixtures.	1, 9, 10	775	79. 6	56	67
	2	855	30. 1	59	89
	3	1, 290	47. 0	87	97
	4	3, 580	44. 4	49	95
	5	1, 630	45. 3	64	82
	6	425	11. 9	65	91
	8	1, 895	70. 1	29	56
	12, 13, 14, 15	195	25. 5	33	92
	17	190	12. 1	38	60
	18, 19, 20	530	23. 1	23	32
Lodgepole pine	1, 9, 10, 15	1, 180	80. 8	48	83
	2, 3, 4, 5	320	39. 4	83	84
	7, 8	585	65. 4	36	81
	12, 13, 14, 19	2, 090	96. 8	72	99
Spruce and firs, including western hemlock and western red cedar except west of Cascades. (For Arizona, Colorado, Utah, and Nevada, the figures are for this type and subalpine combined).	1, 9, 10	1, 685	99. 9	16	100
	2, 3, 4	7, 850	82. 8	64	96
	5	5, 000	100. 0	48	100
	6	455	13. 5	67	92
	7, 16	850	10. 6	48	76
	8	1, 445	19. 5	28	84
	12, 13, 14, 15, 19	1, 260	73. 9	48	97
	18, 20	55	8. 4	54	72
Western white pine	2, 3	3, 860	84. 7	33	96
Subalpine (figures doubtless include some merchantable spruce and fir stands in the Rocky Mountain Region.	1, 9, 10	3, 985	80. 7	99	100
	2, 3, 4, 5	1, 670	65. 1	28	66
	6, 7, 16, 17	130	12. 1	19	37
	8	765	72. 7	70	90
	12, 13, 14, 15, 19	1, 260	73. 9	48	97
	18, 20	55	8. 4	54	72
Woodland.[b] Includes pinon-juniper and digger pine-oak. (Converted on basis 2 cords=1,000 bd. ft.)	6, 16	100	14. 3	24	93
	7, 14, 15	305	39. 3	6	70
	18, 19, 20	510	55. 3	39	87
Brushland.[b] Includes woodland and aspen in some cases.	6, 7, 8, 16	110	9. 0	8	77
	9, 10, 12, 13, 14, 15	160	No data	4	No data
	17	70	36. 3	2	89
	18, 19, 20	10	. 3	0	100
Grass and sage.[b] Includes brushland in regions where no separate figure is given for brush.	1, 9, 10	55	35. 4	19	81
	2, 3, 4, 8	60	13. 3	4	61
	6, 7, 16	10	1. 2	0. 4	12
	11	5	8. 8	7	15
	12, 13, 14	75	79. 3	1	100
	15	270	22. 7	7	100
	17, 18, 19, 20	70	13. 5	2	89
Hardwood	17	90	5. 9	No data	----------
Eastern white pine–red (Norway) pine	21	60	3. 0	18	99
Jack pine[c]	21	205	75. 5	24	77

[a] Based on data in individual fire reports.

[b] Board foot figures for losses in woodland and open types are based on insufficient data and often probably too high. Percentages are based on fewer data than are board foot values.

[c] No data for other types in Lake States.

TIMBER VALUES.—For valuing damages in terms of money, it seems advisable to use general figures where averages are concerned, and not to attempt too great detail in the process. It is considered that practically the same loss is suffered in case of destruction of a given quantity of a given species in a given region, whether the particular stand destroyed is accessible to present logging operations, or whether it is less accessible and consequently of less immediate market value. To put a low estimate on the value of more remote timber would result in low estimates of liability, and therefore in less intensive protection and possible large losses of timber. This would defeat one of the important objects of the national forests, viz, to preserve the less accessible timber until it is needed by the country. Moreover, no one can tell what such stumpage may be worth by the time it becomes marketable. If a stand of timber is destroyed the loss is not merely the value of the timber as such, but includes also its value as part of the productive forest capital. The destruction of a million board feet, wherever located, reduces the forest capital and therefore the potential annual yield of the region.

For the purposes of this study, therefore, arbitrary stumpage values were taken, based largely on appraised or bid prices in large timber sales during the past several years, and supplemented by arbitrary estimates where such basis was lacking (Table VIII). In order to apply these figures in estimating damage in different forest types, which usually contain a mixture of species, composite values by types were set, based on assumed proportions of the different species in the mixture.

VALUE OF YOUNG GROWTH.—The problem of valuing young growth is a very complex one, and can be solved satisfactorily only after a great deal of intensive silvicultural research. Expectation values are purely theoretical, and basis for estimating them is lacking, since our knowledge of yields, rotations, costs of management, and even methods of management, is still almost nil. Cost values, according to standard formulae, based on any costs to which large-scale reforestation operations may be reduced, will in very many, perhaps most, cases give greater values for young growth than the present values of fully stocked stands of mature timber on the same sites.

Except for a few types and regions, reforestation costs fixed on the basis of past and present experience are far too high, and probably do not represent at all what the costs will be when

TABLE VIII.—*Basic stumpage values used for estimating damage done to merchantable timber, by species and types*

Species	Values [a]
Western yellow pine	$2 (2), $2.25 (3), $2.50 (4, 12, 14, 15, 18, 19), $2.75 (7, 8), $3 (6, 11, 16, 17, 20).
Sugar pine	$3.50 (6, 7), $4 (16). Norway pine, $4.50 (21).
White pine	Western $3 (2), $3.50 (4), $4 (3). Eastern, $5.50 (21).
Douglas fir	$1 (3), $1.25 (4, 6, 7, 8), $1.50 (1, 2, 12, 13, 16, 17), $1.75 (5, 9), $2 (10, 14, 15), $2.25 (18, 19, 20).
Western larch	$1.25 (3, 4, 8), $1.50 (2). Eastern larch, $2 (21).
Firs (Abies species)	$0.50 (1, 6, 7, 8, 9), $0.75 (2, 4, 5), $1 (3, 10, 12, 13), $1.25 (16), $1.50 (14, 15), $2 (19, 21), $2.25 (18, 20).
Spruce	$1 (8), $1.50 (1, 2, 5, 9), $1.75 (3, 4, 6, 12), $2 (10, 12, 14, 21), $2.25 (18, 19, 20).
Lodgepole pine	$1.50 (2), $1.75 (1, 9, 12), $2 (3, 4, 7, 8, 10, 13, 14, 15), $3 (6). Jack pine, $2 (21).
Western hemlock	$0.50 (5), $0.75 (4), $1 (3).
Cedar (incense and red)	$0.75 (6, IC), $1 (7, IC, 3, 4, RC), $1.25 (16, IC), $1.50 (2, RC), $2 (5, RC).
Aspen	$1 (12, 13, 14, 15).
Pinon-juniper, oak, etc. [b]	$0.25 (6, 7, 8), $0.30 (12), $0.40 (18, 19), $0.50 (14, 15, 16, 17, 20).

Type	Values [a]
Yellow pine, including sugar pine, etc.	$2 (2), $2.20 (12), $2.25 (3), $2.40 (8), $2.50 (4, 14, 15, 17, 18, 19), $2.60 (6), $2.70 (7), $3 (11, 16, 20).
Douglas fir, and larch—fir.	$1.40 (6, 8), $1.50 (1, 3, 4, 5, 12, 13), $1.75 (2, 9), $2 (10, 14, 15), $2.50 (18, 19, 20).
Lodgepole pine	$1.50 (2, 16), $1.60 (8, 9), $1.75 (1, 4, 7, 12), $2 (3, 6, 10, 13, 14, 15, 19). Jack pine $2 (21).
Spruce and fir, including hemlock, etc.	$0.75 (6, 7), $0.80 (8), $1 (5), $1.20 (9), $1.25 (4), $1.50 (2, 3, 13, 15, 16, 17), $1.60 (14), $1.75 (12), $2 (10), $2.25 (18, 19, 20). Eastern, $2 (21).
White pine	Western, $3.25 (2, 3), Eastern, $5 (21).
Subalpine	$0.50 (1, 2, 3, 4, 5, 6, 7, 8, 9, 16, 17), $1 (10, 12), $1.50 (15), $1.60 (14), $2.25 (18, 19, 20).
Hardwood	$1 (17), $1.50 (21).
Woodland	$0.50 (6, 7) (equivalent to $0.25 per cord). $1 (13, 14, 15, 16, 18, 19, 20).
Open	$0.50 (1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 13), $0.60 (12), $1 (14, 15, 16, 17, 18, 19, 20).

[a] Regions in parentheses. [b] These prices are per cord.

proper methods have been worked out. However, costs are about the only tangible basis we have for valuing young stands.

In view of the many intangible values which can not be expressed in money, it seems fairly reasonable to use cost value for young growth as representing not only its value as potential timber but also the other forest values. This is on the theory that if the forest cover is to be maintained on a given site, it is worth at least what it would cost to put it there—if not for its timber value, then for other purposes, such as protection of watersheds. It seems quite possible that a portion of our Rocky Mountain forests will never yield enough timber to repay the costs of establishment and administration, unless timber values rise much higher than it seems reasonable to suppose. But because of their other values, which are of even greater importance, they will always be protected and maintained as forest. Cost of establishment as used here is not taken to mean the cost of growing the stand to maturity, or even to the age of that destroyed, but is merely the cost of getting young growth established. For use in figuring past losses, general values for the different types and regions were worked out by the following arbitrary method.[3]

Costs of replanting were set, based in part on results of planting operations on the national forests during a number of pre-war years, but mostly on arbitrary estimates of what replanting should cost if done immediately after a burn, and assuming that the proper technique had been developed (Table IX).

It was assumed that, taken by and large, one-half of the reproduction areas destroyed by fire will restock naturally within an average period of 10 years, and one-half not at all. Exceptions are lodgepole pine, jack pine, and the woodland types, of which it was assumed three-fourths will restock within 10 years and the rest not at all. Other exceptions are the western yellow pine type in the Great Basin and in the Southwest, and the scattered timber in the brush and grass types of all regions, of which it was assumed that but one-fourth will restock within 10 years.

The cost of restocking was then taken to be the cost of planting, plus compound interest at 3 per cent for 10 years. In case of destruction of young growth which will not restock naturally, the loss will be this figure; where natural restocking will take place the loss will be merely the 10 years' interest. This "rule-of-thumb" method gives the following results, "A" being area in acres and "C" the cost of planting per acre:

Where the entire area will restock naturally ..... 0.3439 AC, or 0.35 AC.
Where three-fourths of the area will restock naturally ..... .5939 AC, or 0.60 AC.
Where one-half of the area will restock naturally ..... .8439 AC, or 0.85 AC.
Where one-fourth of the area will restock naturally ..... 1.0939 AC, or 1.10 AC.

It is admitted that this method is not entirely scientific, but it is expected to give about as good a basis for valuing relative damage which has occurred over considerable areas and periods as we can get with the data available at present.

With the data described above (Tables VII, VIII, IX), the average monetary damage per acre was computed for the different types of forest and other cover within the several regions. (Table X.)

TABLE IX.—*Assumed costs of replanting, used as basis for estimating damage to young growth*

Forest type	Cost per acre to restock [a]
Western yellow pine, including sugar pine mixtures, etc.	$6 (3), $7 (2), $8.50 (11), $10 (1, 4, 6, 7, 8, 9, 10), $12 (12, 13, 16), $15 (14, 15, 17, 18, 19, 20).
Douglas fir, including western larch.	$6 (2), $7.50 (5, 6), $8 (3), $10 (1, 4, 7, 8, 9, 10, 12, 13, 16), $12 (18, 19, 20), $15 (14, 15), $20 (17).
White pine (W. and E.)	$5 (2), $6 (3), $6 (21). Norway pine, $6 (21).
Lodgepole pine	$8 (2, 3, 6), $10 (1, 4, 7, 8, 9, 10, 12, 13, 14, 15).
Jack pine	$10 (21).
Spruce	$5.50 (3), $6 (2), $6.50 (1, 9, 10), $8 (4, 7, 8), $10 (12, 13, 14, 15, 18, 19, 20).
Firs	$6 (2, 3, 21), $7.50 (4, 5, 6, 7, 8), $8 (16).
Subalpine	$6 (2, 3), $8 (4, 5, 6, 7, 8, 16), $10 (1, 9, 10, 12, 13, 14, 15).
Woodland	$5 (6, 12, 13, 14, 15, 16, 18, 19, 20).

[a] Regions in parentheses.

[3] A method for valuing young growth for use in making fire plans and in fire reports in the future is outlined in the discussion (pp. 759–760) on "Destructible values."

TABLE X.—*Average value of timber and young growth destroyed per acre burned over*

Region	Forest type								
	Western yellow pine and sugar pine	Douglas fir and larch	Lodge-pole pine	Spruce and firs	White pine	Sub-alpine	Wood-land	Brush	Grass
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
1		5.92	4.95			10.40		[a]0.29	0.29
2	4.75	4.45	4.63	14.97	14.20	2.24		.29	.29
3	4.36	8.03	4.79	14.65	14.20	2.24		.29	.29
4	5.13	9.44	5.54	13.97		2.80		.47	.47
5		6.61		8.12		3.86			
6	6.15	4.82	2.97	4.72		1.40	1.22	.78	.04
7	5.27		3.18	3.76		1.40	.33	.78	.04
8	8.23	5.12	3.10	3.12		5.28		.94	.47
9		6.12	4.77	2.90		10.40		[c].30	[c].30
10		6.31	5.24	4.25		12.39		[c].30	[c].30
11	2.95							.65	.65
12	3.37	3.10	7.98	6.29		3.01			.28
13		3.20	8.50	5.97			.28	.28	.15
14	4.20	4.68	12.10	6.10			1.68	.53	.53
15	8.22	8.83	5.24	5.97		5.97	.48	.68	1.18
16	4.59		2.68	4.64		1.40	.82	.99	.05
17	7.12	6.75				1.40	[b].09	.51	.51
18	4.74	3.62		4.71		4.71	1.68	.34	.40
19	4.74	3.62	8.50	4.71		4.71	1.68	.34	.40
20	9.18	3.62		4.71		4.71	1.68	.34	.40
21			[d]1.85	[d]1.20	1.20		[e]1.20	.10	[c].10

[a] Estimated, data unsatisfactory.
[b] Hardwood bottoms.
[c] Jack pine.
[d] Spruce, balsam, tamarack, value estimated same as eastern white pine.
[e] Hardwoods, value estimated same as eastern white pine.

RATING THE LIABILITY

Rating of the liability of a given individual unit involves two different processes. One is the rating of the general liability, or the liability due to general risk fires. which may be considered as an average figure generally applicable to the entire area of a given type within one region. The other process is the rating of the special liability due to special risk fires, which can not be applied generally but will be different for each specific unit. In each of these cases the rating should include the total liability of each sort, i. e., the liability of loss, plus the suppression liability.

GENERAL LIABILITY—Since the general risk has been assumed to be spread fairly evenly over the whole extension of a given type within one region, the general liability will be uniform for equal areas of the type, provided they are subject to the same "hour control," no matter which individual forest unit within that region may be under consideration. This liability will be the product of the sum of probable average loss plus probable average suppression cost per fire for the given hour control, multiplied by the average number of fires per year per unit of area of the given type, and can be computed as follows:

1. Average sizes of fires for different hour-control periods are shown in Figures 4–18.

2. Average damage per acre burned over is found in Table X. The products of these two sets of figures give average damage per fire.

3. Average suppression costs per fire for different hour control periods are given in Table VI.

4. The average numbers of general risk fires per 1,000 acres of each type and region are given in Table XI.

5. The sums of damages and costs, found as outlined above, multiplied by number of fires, gives the general liability per 1,000 acres for each type and region according to different hour controls. These values are given in Table XII.[4]

[4] Tables were also prepared for regions 1, 5, 7, 9, 10, 11, 13, 14, 15, 18, and 20, but are omitted because of the rather inadequate data on which they are based.

TABLE XI.—*Average number of general risk fires on national forests per year per 1,000 acres, by regions and forest types, 1911–1915*

Region	Forest types								
	Yellow pine, etc.	Douglas fir, etc.	Lodge-pole pine	Fir, spruce, etc.	White pine	Sub-alpine	Wood-land	Brush	Grass and sage
1		0.00582	0.00541			0.00418		0.00522	0.00522
2	0.03146	.01015	.00766	0.00952		.00569		.01231	.01231
3	.04059	.02391	.01843	.03113	0.06294	.04644		.01989	.01989
4	.05188	.02441	.01956	.04806		.01859		.10937	.10937
5		.01077	.01378	.04203		.01378			
6	.07316	.10559		.11850		.04215	0.02857	.09584	.13636
7	.06667		.01774	.08955		.04706	.01048	.02179	.01405
8	.03645	.01548	.01359	.00451		.00993		.00601	.01333
9		.00630	.00813	.02326		.00327		.00907	.00907
10		.00420	.00456	.00347		.00071		.00462	.00462
11	.05227							.01724	.01724
12	.01281	.03077	.00682	.00239		.00252	.01149	.01149	.01149
13		.03333	.00926	.00385			.00077	.00077	.00627
14	.00485	.00306	.00162	.00393		.00393	.00061	.00402	.00402
15	.02186	.02326	.00980	.00256		.00256	.00102	.00221	.00495
16	.05064	.05064	.00601	.07692		.01119	.02817	.04112	.07752
17	.05952	.03604				.03846	[a].13194	.02531	[b].25641
18	[c].04252	.04252		.04252		.04252	.00767	.00133	.00133
19	[c].00717	.00717	.00435	.00717		.00717	.00421	.00200	.00200
20	[c].03806	.03806		.03806		.03806	.00374	.00361	.00361
21			[d].01842	.00475	.06250		[e].01081	.10000	.10000

[a] Hardwood bottoms.
[b] Doubtful.
[c] Same figure for all timber types, because no basis for separating them.
[d] Jack pine.
[e] Hardwood.

TABLE XII.—*Total general liability per 1,000 acres by control periods*

REGION 2—WESTERN MONTANA

Hour control	Forest types						
	Western yellow pine	Douglas fir and larch	Western white pine[a]	Lodgepole pine	Spruce and fir	Subalpine	Open
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	0.79	0.24	3.52	0.14	0.14	0.07	0.19
1	1.26	.44	6.10	.21	.17	.10	.27
2	2.33	.85	8.50	.31	.21	.12	.40
3	3.02	1.27	10.51	.40	.24	.14	.50
4	3.65	1.57	12.65	.43	.28	.15	.60
5	4.28	1.85	15.11	.46	.32	.16	.68
6	4.94	2.07	17.25	.59	.36	.17	.75
7	5.57	2.35	19.76	.91	.41	.18	.84
8	6.20	2.69	23.41	1.19	.47	.20	.92
9	7.05	3.04	25.55	1.40	.52	.24	.99
10	7.90	3.41	29.52	1.62	.59	.42	1.07
12	9.50	4.08	32.86	2.07	.75	.65	1.23
15	12.46	5.12	39.21	2.87	.92	.84	1.53
20	17.71	6.78	52.18	4.43	1.34	1.06	2.09

[a] Region 3 figures used for white pine type, because data for this region are insufficient.

TABLE XII.—*Total general liability per 1,000 acres by control periods*—Contd.

REGION 3—NORTHERN IDAHO

Hour control	Forest types						
	Western yellow pine	Douglas fir and larch	Western white pine	Lodgepole pine	Spruce, cedar, fir, hemlock	Subalpine	Grass and brush
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	0.97	1.39	3.52	0.42	0.43	0.56	0.30
1	1.54	2.54	6.10	.57	.56	.79	.44
2	2.87	4.76	8.50	.81	.68	1.02	.66
3	3.68	5.92	10.51	1.08	.81	1.11	.82
4	4.41	7.65	12.65	1.12	.90	1.21	.98
5	5.22	8.70	15.11	1.22	1.06	1.30	1.09
6	5.99	9.45	17.25	1.53	1.15	1.39	1.21
7	6.75	10.28	19.76	2.40	1.31	1.49	1.35
8	7.52	11.41	23.41	3.07	1.46	1.62	1.49
9	8.57	12.22	25.55	3.54	1.68	2.00	1.59
10	9.68	13.22	29.52	4.09	1.93	3.45	1.73
12	11.65	15.23	32.86	5.29	2.43	5.34	1.99
15	15.08	18.53	39.21	7.17	2.99	6.87	2.47
20	21.43	24.91	52.18	11.00	4.36	8.68	3.38

TABLE XII.—*Total general liability per 1,000 acres by control periods*—Contd.

REGION 4—EASTERN WASHINGTON

Hour control	Forest types					
	Western yellow pine	Douglas fir and larch	Lodgepole pine	Spruce fir, hemlock, cedar	Subalpine	Grass and brush
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	1.56	0.81	0.59	1.54	0.22	5.91
1	2.39	1.17	.64	2.40	.32	7.77
2	3.71	1.66	.72	3.32	.45	10.06
3	6.48	2.27	1.00	3.92	.56	13.12
4	9.44	3.15	1.64	4.62	.59	15.97
5	12.92	5.10	2.05	5.29	.61	19.58
6	16.81	8.08	2.42	5.87	.63	23.30
7	21.37	13.86	2.82	6.44	.67	27.67
8	26.77	21.72	3.17	7.35	.69	32.33
9	32.32	32.03	3.66	8.27	.71	37.41
10	38.70	43.40	4.17	9.23	.74	42.33
12	52.24	72.45	5.36	10.19	1.04	54.70
15	78.28	129.96	7.12	12.69	1.73	72.08
20	130.05	264.53	11.11	16.77	3.27	116.05

REGION 6—SOUTHERN OREGON AND NORTHERN CALIFORNIA COAST RANGES

Hour control	Forest types						
	Western yellow pine	Douglas fir	Red and white fir	Subalpine	Digger pine and oak	Brush	Grass
	Dolls.	*Dolls*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	3.80	2.32	1.66	0.34	5.03	4.79	3.82
1	6.51	3.06	1.90	.34	6.71	6.80	4.77
2	10.83	4.65	2.25	.38	8.51	9.29	5.73
3	15.22	9.71	2.61	.38	10.11	12.08	6.70
4	19.68	14.36	2.84	.38	11.91	14.57	7.50
5	24.29	19.32	3.32	.42	13.89	16.96	8.45
6	28.90	23.76	5.10	.42	16.06	19.36	9.68
7	33.43	28.01	7.58	.42	18.46	21.56	10.77
8	38.04	31.57	8.89	.42	20.94	23.96	11.86
9	42.58	34.63	10.07	.46	23.49	26.36	13.09
10	47.04	38.36	10.90	.46	26.40	29.04	14.45
12	56.33	44.88	12.44	.51	32.54	35.17	17.45
15	64.45	56.38	14.70	.55	42.94	45.33	22.09
20	102.42	77.24	20.50	.76	63.77	64.70	31.23

TABLE XII.—*Total general liability per 1,000 acres by control periods*—Contd.

REGION 8—EASTERN OREGON AND SOUTHWESTERN IDAHO

Hour control	Forest types						
	Western yellow pine	Douglas fir and Larch	Lodgepole pine	Spruce, fir, etc.	Subalpine	Brush	Grass
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	1.45	0.28	0.30	0.12	0.13	0.60	0.72
1	2.22	.42	.34	.18	.19	.79	.93
2	4.05	.55	.37	.24	.27	1.05	1.23
3	6.49	.82	.50	.28	.34	1.37	1.60
4	9.59	1.14	.79	.32	.36	1.69	1.95
5	13.27	1.84	.95	.35	.38	2.07	2.37
6	17.50	2.90	1.13	.38	.40	2.48	2.84
7	22.38	4.97	1.29	.41	.42	2.95	3.37
8	28.17	7.89	1.44	.45	.44	3.45	3.96
9	34.51	11.36	1.64	.48	.45	3.99	4.56
10	41.08	15.32	1.86	.52	.48	4.53	5.16
12	55.92	25.28	2.35	.56	.78	5.83	6.65
15	84.38	44.82	3.10	.65	1.19	8.05	9.19
20	141.10	89.86	4.73	.79	2.33	12.45	14.13

REGION 12—EASTERN COLORADO

Hour control	Forest types					
	Western yellow pine	Douglas fir	Lodgepole pine	Engelmann spruce	Subalpine	Grass and brush
	Dolls	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	0.24	0.86	0.25	0.08	0.02	0.18
1	.31	1.11	.42	.10	.03	.26
2	.42	1.88	.83	.13	.05	.38
3	.50	2.52	1.21	.17	.07	.47
4	.55	3.08	1.71	.19	.08	.56
5	.67	3.72	2.31	.22	.09	.67
6	.78	4.46	2.90	.25	.11	.77
7	1.04	5.26	3.61	.28	.12	.89
8	1.39	6.09	4.36	.31	.13	1.00
9	1.79	6.99	5.22	.35	.14	1.15
10	2.21	8.00	6.05	.39	.15	1.29
12	3.20	10.06	8.13	.46	.16	1.60
15	5.05	13.91	11.63	.60	.21	2.16
20	9.49	21.35	19.19	.84	.28	3.25

TABLE XII.—*Total general liability per 1,000 acres by control periods*—Contd.

REGION 16—WEST SLOPE OF SIERRAS

Hour control	Forest types: Western yellow and sugar pines	Red and white fir	Lodgepole pine	Subalpine	Digger pine and oak	Brush	Grass
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	2.08	0.92	0.20	0.01	3.80	6.43	4.50
1	4.15	1.69	.38	.01	4.85	7.76	5.27
2	7.04	2.54	.62	.02	5.97	9.88	5.97
3	9.72	2.77	.83	.02	7.04	11.62	6.59
4	12.26	2.92	1.03	.02	8.28	13.16	7.29
5	14.79	3.08	1.23	.02	9.61	14.45	7.91
6	16.66	3.23	1.37	.02	11.04	15.90	8.60
7	18.28	3.38	1.50	.02	12.34	17.62	9.23
8	19.65	3.46	1.60	.02	14.25	19.37	10.00
9	21.32	3.54	1.73	.02	15.97	21.05	10.54
10	22.99	3.69	1.86	.03	17.72	22.98	11.18
12	25.57	3.92	2.04	.03	20.47	27.22	12.35
15	30.74	4.15	2.33	.04	27.92	33.56	14.19
20	41.07	4.77	3.21	.09	41.32	46.77	18.22

REGION 17—SOUTHERN CALIFORNIA

Hour control	Forest types: Western yellow pine	Fir and pine slopes	Subalpine	Hardwoods	Chaparral	Grass,[a] etc.
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls*	*Dolls.*
½	2.92	3.31	0.04	4.22	6.25	21.28
1	5.24	7.62	.04	7.26	7.79	28.97
2	10.54	17.44	.08	11.34	9.47	36.15
3	16.25	25.51	.08	14.65	11.13	44.62
4	21.49	33.33	.08	16.62	12.68	54.62
5	26.90	41.19	.08	17.94	14.35	60.51
6	32.80	51.28	.08	18.60	16.02	76.67
7	38.45	62.57	.08	19.26	17.90	88.97
8	43.75	75.10	.08	19.92	20.00	102.82
9	48.28	87.60	.08	20.58	22.15	117.18
10	53.10	101.36	.11	21.62	24.28	134.10
12	62.14	132.11	.11	23.22	29.03	167.95
15	79.70	186.34	.15	25.33	37.21	229.49
20	115.42	298.27	.31	28.63	53.00	349.49

[a] Data on area very unsatisfactory; figures doubtless too high.

TABLE XII.—*Total general liability per 1,000 acres by control periods*—Contd.

REGION 19—SOUTHWESTERN COLORADO AND NORTHERN NEW MEXICO

Hour control	Forest types: Yellow pine	Douglas fir	Spruce and subalpine	Lodgepole pine	Pinon-juniper	Brush	Grass
	Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
½	0.19	0.13	0.32	0.16	0.01	0.02	0.03
1	.31	.21	.48	.28	.01	.02	.05
2	.60	.38	.61	.55	.02	.03	.08
3	.97	.65	.92	.80	.02	.03	.12
4	1.41	.93	1.06	1.14	.02	.04	.17
5	1.93	1.27	1.21	1.54	.03	.05	.23
6	2.53	1.66	1.32	1.94	.03	.06	.30
7	3.20	2.09	1.46	2.41	.03	.06	.38
8	3.98	2.57	1.60	2.92	.03	.07	.47
9	4.85	3.10	1.73	3.51	.04	.08	.57
10	5.72	3.66	1.86	4.07	.05	.09	.68
12	7.99	4.88	2.17	5.47	.05	.12	.92
15	11.81	7.27	2.60	7.84	.06	.16	1.37
20	21.41	12.27	3.41	12.95	.09	.23	2.29

REGION 21—LAKE STATES[a]

Hour control	Forest types: Eastern white and red pines	Jack pine	Spruce, balsam, tamarack	Hardwood	Open
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
½	3.62	13.96	0.28	0.63	0.80
1	5.00	20.83	.38	.86	1.00
2	8.19	28.53	.62	1.42	1.20
3	12.12	37.97	.92	2.10	1.60
4	17.00	49.98	1.29	2.94	1.90
5	22.62	61.97	1.72	3.94	2.30
6	28.75	75.67	2.19	4.97	2.80
7	35.75	92.12	2.72	6.18	3.20
8	43.56	109.23	3.31	7.53	3.70
9	52.12	128.73	3.96	9.02	4.20
10	61.19	147.51	4.65	10.58	4.90
12	82.00	196.29	6.23	14.18	6.10
15	119.31	263.87	9.07	20.64	8.30
20	196.50	419.46	14.93	33.99	12.70

[a] All figures on areas very doubtful, and these values are therefore not very satisfactory.

To use these figures in estimating the general liability of a given forest unit it will be necessary to know the area and location of the different types of forest cover within the unit, and the hour-control that will be effected for all parts of the unit with the existing or proposed protective organization. Thus, the fire plan might show a forest in western Montana something like this:

Forest type	Area	Hour control	General liability
	Acres	*Hours*	*Dollars*
Western yellow pine	100,000	Less than 1	79.00
	50,000	2	116.50
	50,000	3	151.00
	50,000	4	182.50
Douglas fir	50,000	2	42.50
	100,000	4	157.00
	200,000	6	414.00
	50,000	12	204.00
Lodgepole pine	100,000	6	59.00
	50,000	8	59.50
Subalpine	50,000	10	21.00
	50,000	15	42.00
Total general liability for the forest			1,528.00

This means that, with the given amount of protection, the average annual loss plus suppression cost for general risk fires, for a period of years, ought to be about $1,500; some years might run above, others below this figure. It is hardly necessary to say that the example given is for a purely imaginary forest.

SPECIAL LIABILITY.—Rating of the special liability will be done in a slightly different way. It is not uniform for the whole area of a given type within a region, but is confined only to those parts of the type which are exposed to the fixed risks and varies for different units as the chance of occurrence of fires varies. In order to rate a unit it will be necessary to know what areas of each type are exposed to special risks, how many fires per year can be expected in each, and what hour control will be provided by the existing or proposed protection organization. The number of fires per year will be based on the average number which have occurred in that particular unit during a period of years, making due allowance for changes in the hazard, such as adoption of spark arresters or of fuel oil, or construction of effective fire lines along railroads. The special liability will then be the products of losses plus costs per fire for different hour control periods, found in the same way as described under general liability, multiplied by the number of special risk fires. For example, let us take the hypothetical western forest already described. We find that areas exposed to special risks are as follows:

Class of risk, forest type, and area	Hour control	Fires per year	Loss plus cost per fire	Product
Railroad fires:				
Yellow pine type—	*Hours*	*Number*	*Dollars*	*Dollars*
50,000 acres	Less than 1	25	25.25	631.25
20,000 acres	2	10	74.50	745.00
Douglas fir type—				
20,000 acres	2	5	83.60	418.00
Total liability due to railroad				1,794.25
Lumbering operations:				
Yellow pine type—				
25,000 acres	Less than 1	8	25.25	202.00
Douglas fir type—				
50,000 acres	2	7	83.60	585.20
Total liability due to lumbering				787.20
Total special liability				2,581.45

TOTAL GENERAL AND SPECIAL LIABILITY.—Having found the general and the special liabilities for the unit in the manner described, the total liability from all causes is their sum, or in the illustration given, $1,528 plus $2,581.45, or $4,109.45. It will be noticed that nowhere in this method of rating has any allowance been made for variations in the factor of efficiency. This appears to be justified for at least two reasons. The grouping together of the fires on several of the national forests and for periods of several years in studying the past records should have evened out differences in efficiency as far as past performance is concerned, and in figuring on future organizations we should assume these differences to grow no greater, and probably less.

LENGTH OF FIRE SEASON

The cost of maintaining a protective organization will be governed partly by the length of the period during which it must be effective. This of course depends upon the length of the danger period in the different units. The occurrence of general risk fires per unit of area (per 1,000,000 acres) in the different types and subregions, by 10-day periods, is shown in Table XIII. If it be assumed that the fire season, the period during which the protective organization should be effective, is marked by the period during which more than one fire per million acres occurs in each 10-day period, the fire seasons for the different types and regions will be found indicated under "Fire danger A" in each section of the table. A smaller number of fires per 10-day period ought to be handled effectively by the regular administrative organization, without seriously interfering with their other work. If the standard is set at some point greater than one per 10 days, it will cut down the fire seasons accordingly. (See "Fire danger B," Table XIII.)

TABLE XIII.—*Average number of general risk fires per year, per million acres, by 10-day periods* [a]

REGION 2—WESTERN MONTANA

Period	Number of fires, by forest types						
	Western yellow pine	Douglas fir and larch	Western white pine	Lodgepole pine	Spruce and fir	Subalpine	Grass and brush
Apr. 21–30				0.2			
May 1–10		0.1					0.6
11–20	0.2						
21–31		.1					
June 1–10	.2	.1					
11–20	.5	.2		0.1		0.2	
21–30	1.4	.8		.5		.2	.6
July 1–10	.2	.1		.2		.3	.6
11–20	2.5	.5		.3	0.6	.2	1.3
21–31	4.1	2.5		.7	2.5	.6	.6
Aug. 1–10	6.0	3.1	3.0	2.1	1.3	1.0	1.3
11–20	8.3	2.3		1.2		1.8	3.2
21–31	6.9	3.3		1.6	1.3	1.3	3.2
Sept. 1–10	1.6	.4		.8	1.3		.6
11–20	.9	.1		.1			.6
21–30	1.2	.1					.6
Oct. 1–10				.1			
11–20		.1					
21–31	.2						
Nov. 1–10							
11–20							
21–30		.1					
Danger periods A.[b]	June 21–30; July 11–Sept. 30.	July 21–Aug. 31.	Aug. 1–10.	Aug. 1–31.	July 21–Sept. 10.	Aug. 1–31.	July 11–20; Aug. 1–31.
Danger periods B.[b]	July 21–Aug. 31.	Aug. 1–31.	Aug. 1–10.	None.	None.	None.	Aug. 11–31.

[a] Tables were prepared also for Regions 1, 5, 7, 9, 10, 11, 13, 14, 15, 18, and 20, but are omitted because of the rather inadequate data on which they were based.

[b] Danger periods A are the periods during which one or more than one fire occurs in 10 days. Danger periods B are the periods within which three or more fires occur in 10 days, or two fires or more a week.

TABLE XIII.—*Average number of general risk fires per year, per million acres, by 10-day periods*—Continued

REGION 3—NORTHERN IDAHO

Period	Number of fires, by forest types						
	Western yellow pine	Douglas fir and larch	Western white pine	Lodge-pole pine	Spruce, hemlock, fir, cedar	Sub-alpine	Brush and grass
Apr. 11-20	0.9						
21-30							
May 1-10							
11-20		0.1	0.2		0.8		
21-31	.9						
June 1-10		.1	.4				
11-20		.3	.6				0.4
21-30	.9	.1	1.2		1.6		
July 1-10	.9	.2		0.9		0.6	
11-20		1.0	4.2	.9	1.6	1.7	.4
21-31	9.8	5.7	8.6	2.8	2.4	4.4	2.6
Aug. 1-10	6.2	3.2	13.0	6.6	7.2	3.8	1.8
11-20	8.0	4.4	13.2	5.6	6.4	12.9	5.7
21-31	16.9	5.3	17.0	2.8	4.0	10.2	4.8
Sept 1-10	8.0	1.7	4.2		4.8	2.6	1.3
11-20	1.8	.1	.6			.3	
21-30							.4
Danger periods A [b]	July 21-Sept. 20	July 11-Sept. 10	June 21-30; July 11-Sept. 10	July 21-Aug. 31	June 21-30; July 11-Sept. 10	July 11-Sept. 10	July 21-Sept. 10
Danger periods B [b]	July 21-Sept. 10	July 21-Aug. 31	July 11-Sept. 10	Aug. 1-20	Aug 1-Sept. 10	July 21-Aug. 31	Aug. 11-31

REGION 4—EASTERN WASHINGTON

Period	Number of fires, by forest types					
	Western yellow pine	Douglas fir and larch	Lodgepole pine	Spruce, hemlock, cedar, white fir	Sub-alpine	Grass and brush [c]
May 11-20	0.6					
21-31						
June 1-10	1.7	0.5				
11-20	2.8	.2		1.6		2.0
21-30	7.8	1.2	4.2	1.6	0.5	2.0
July 1-10	7.8	2.2	4.2	3.1	2.3	
11-20	6.2	2.7		2.3	.9	
21-31	17.4	4.9		8.6	9.2	2.0
Aug. 1-10	7.3	4.4	4.2	7.8	2.3	
11-20	6.2	4.4		11.7	1.4	2.0
21-31	11.8	5.9	12.6	18.7	.9	6.0
Sept. 1-10	6.7	1.9		3.9		6.0
11-20	3.9			1.6		
21-30	2.2			.8	.5	6.0
Oct. 1-10	2.8	.2				
11-20						2.0
21-31	.6					
Nov. 1-10	.6					
Danger periods A [b]	June 1-Oct. 10	June 21-Sept. 10	June 21-Aug 31	June 11-Sept. 20	July 1-Aug. 20	June 11-Oct. 20
Danger periods B [b]	June 21-Sept. 20	July 21-Aug. 31	Same as A.	July 1-Sept. 10	July 21-31	Aug. 21-Sept. 30

[b] Danger periods A are the periods during which one or more than one fire occurs in 10 days. Danger periods B are the periods within which three or more fires occur in 10 days, or two fires or more a week.
[c] Data on area of this type very unsatisfactory, therefore figures are little better than a guess.

TABLE XIII.—*Average number of general risk fires per year, per million acres, by 10-day periods*—Continued

REGION 6—SOUTHERN OREGON AND NORTHERN CALIFORNIA COAST RANGES

Period	Number of fires, by forest types							
	Western yellow pine	Western yellow and sugar pines	Douglas fir	Fir and lodge-pole	Sub-alpine	Digger pine and oak	Brush	Grass
Mar. 11-20		0.2						
21-31								
Apr. 1-10		.3						
11-20		.3					0.2	
21-30		.5						
May 1-10		.5	0.3				.2	
11-20	1.8	1.2	.8	0.7			.4	
21-31	1.0	1.9	.3	2.7		0.9	.6	
June 1-10	2.8	2.6	1.1	.7		.9	1.1	4.4
11-20	1.0	1.6		1.3			.4	
21-30		1.0	.3	.7			.6	
July 1-10	5.3	7.7	3.1	8.0		.9	4.4	13.2
11-20	3.9	6.1	6.2	4.0	3.9	2.8	3.2	13.2
21-31	7.4	9.5	7.8	7.4	3.9	.9	5.6	4.4
Aug. 1-10	6.8	4.7	4.8	3.3		11.4	8.9	8.8
11-20	4.2	9.1	8.1	10.7	3.9	.9	11.6	13.2
21-31	7.7	10.2	20.7	22.8	11.7	9.5	13.8	13.2
Sept. 1-10	1.8	4.6	5.9	1.3		2.8	4.4	4.4
11-20	1.8	2.1	2.2	2.0		1.9	8.4	
21-30	1.8	3.3	3.9	1.3		4.7	4.7	
Oct. 1-10	.4	3.3	2.8	4.0			6.8	
11-20	1.4	2.3	7.0	2.0			7.0	4.4
21-31	1.0	1.4	.6			.9	1.7	30.8
Nov 1-10	.4	.2					.6	
11-20	.4	.7						
21-30	1.4	.2					.8	
Danger periods A [b]	May 11-June 20; July 1-Sept 3); Oct. 11-31; Nov. 21-30	May 11-Oct. 31	June 1-10; July 1-Oct. 20	May 21-31; June 11-20; July 1-Oct. 20	July 11-31; Aug. 11-31	July 11-Sept 30	June 1-10; July 1-Oct. 31	June 1-10; July 1-Sept. 10; Oct. 11-31
Danger periods B [b]	July 1-Aug. 31	July 1-Sept. 10; Sept. 21-Oct. 10	July 1-Sept. 10; Sept. 21-30; Oct. 11-20	July 1-Aug. 31; Oct. 1-10	Same as A	Aug. 1-10; Aug. 21-31; Sept 21-30	July 1-Oct. 20	Same as A

REGION 8—EASTERN OREGON AND SOUTHWESTERN IDAHO

Period	Number of fires, by forest types						
	Western yellow pine	Douglas fir and larch	Lodge-pole pine	Spruce, white fir (cedar)	Subalpine	Brush	Grass and sage
Apr. 21-30	0.1						
May 1-10	.1						
11-20							
21-31	.3						
June 1-10							
11-20	.5						
21-30	.5		0.1				0.3
July 1-10	.5	0.1	.2		0.3		.7
11-20	1.2	.2	.6			1.0	1.3
21-31	3.6	1.5	1.9	0.5	.6		.7
Aug. 1-10	7.4	3.1	1.9	2.5	1.1	1.0	1.7
11-20	7.7	2.4	2.4	.5	2.2	2.0	1.7
21-31	6.9	2.9	1.9		1.9	1.0	3.0
Sept. 1-10	4.0	1.8	2.0		.8		2.3
11-20	.9	.9	.2	.5	.6		.7
21-30	.5	.3	.1		.5		
Oct. 1-10	.3		.3				
11-20	.1						
21-31	.1	.1	.1				
Nov. 1-10	.1						
Danger periods A [b]	July 11-Sept. 10	July 21-Sept. 10	July 21-Sept. 10	Aug. 1-10	Aug. 1-31	July 11-Aug. 31	July 11-Sept. 10
Danger periods B [b]	July 21-Sept 10	Aug. 1-10	None.	None.	None.	None.	Aug. 21-31

[b] Danger periods A are the periods during which one or more than one fire occurs in 10 days. Danger periods B are the periods within which three or more fires occur in 10 days, or two fires or more a week.

TABLE XIII.—*Average number of general risk fires per year, per million acres, by 10-day periods*—Continued

REGION 12—EASTERN COLORADO

Period	Number of fires, by forest types					
	Western yellow pine	Douglas fir	Lodgepole pine	Engelmann spruce	Subalpine	Grass and brush
Mar. 21–31						0.9
Apr. 1–10	0.2					
11–20				0.2		
21–30						
May 1–10	.2		0.4			
11–20						
21–31	1.2	3.1		.5		
June 1–10	.7		.4		4.0	
11–20	.5	3.1	.4	.2	4.0	.9
21–30	.9		1.3	.2	4.0	2.6
July 1–10	2.3	9.2	1.8	.2	8.0	.9
11–20	.9		.9			
21–31	.7	3.1	.4	.5		
Aug. 1–10	1.6	3.1	.9			.9
11–20	.7					.9
21–31	.7	6.1	.4		4.0	
Sept. 1–10	.7	3.1	1.3			
11–20	.5		.4			.9
21–30	.2		.4			
Oct. 1–10	.9	3.1				.9
11–20	.5	3.1				
21–31			.4	.2		
Nov. 1–10				.2		.9
11–20	.7		.4	.2		
21–30						.9
Danger periods A [b]	May 21–31; July 1–10; Aug. 1–10.	May 21–31; June 11–20; July 1–10; July 21–Aug. 10; Aug. 21–Sept. 10; Oct. 1–20.	June 21–July 10; Sept. 1–10.	None.	June 1–July 10; Aug 21–31.	June 21–30.
Danger periods B [b]	None.	Same as A.	None.	None.	Same as A.	None.

[b] Danger periods A are the periods during which one or more than one fire occurs in 10 days. Danger periods B are the periods within which three or more fires occur in 10 days, or two fires or more a week.

TABLE XIII.—*Average number of general risk fires per year, per million acres, by 10-day periods*—Continued

REGION 16—WEST SLOPE OF SIERRAS

Period	Number of fires, by forest types						
	Western yellow pine	Western yellow and sugar pines and Douglas fir	Red and white fir	Lodgepole pine and subalpine	Digger pine and oak	Brush	Grass
Feb. 21–28/29		0.5				0.2	
Mar. 1–10	0.3						
11–20	1.0	.1					
21–31							
Apr. 1–10							
11–20	.3						
21–30		.2					
May 1–10		.1					1.7
11–20	.8	.2			1.0	0.2	1.7
21–31	1.3	.4			3.1	1.3	
June 1–10	3.1	2.0	1.5		3.1	.4	3.4
11–20	4.2	1.3	3.0	0.3		.6	1.7
21–30	1.0	1.2		.6		1.5	13.6
July 1–10	3.9	1.3	4.0			4.4	8.5
11–20	4.9	4.4	12.0	.3		4.1	8.5
21–31	7.0	4.5	7.0	.6	1.0	5.7	10.2
Aug. 1–10	9.4	3.9	8.5	.8	5.2	5.0	10.2
11–20	10.4	4.5	7.0	1.1	2.1	8.3	5.1
21–31	14.8	9.8	16.5	2.2	4.2	5.2	3.4
Sept. 1–10	5.2	4.1	6.5	.6	2.1	5.2	1.7
11–20	7.3	4.9	7.0	.6	3.1	3.5	5.1
21–30	12.0	3.3	6.5	.6	1.0	4.1	3.4
Oct. 1–10	4.7	1.7	3.0	.3		2.6	5.1
11–20	4.9	1.3	1.0		1.0	.9	
21–31	2.9	2.6			1.0		
Nov 1–10	1.0	.6	.5			.2	1.7
11–20	.3					.2	1.7
21–30	.3	.2					
Dec. 1–10		.2					
11–20		1					
Danger periods A.[b]	May 21–Nov. 10.	June 1–Oct. 31.	June 1–20; July 1–Oct. 20.	Aug. 11–31.	May 21–June 20; July 21–Sept. 30; Oct. 11–31.	June 1–10; July 1–Oct. 20.	May 11–31; June 11–Oct. 20; Nov. 11–31.
Danger periods B.[b]	June 1–20; July 1–Oct. 20.	July 11–Sept. 30.	June 11–20; July 1–Oct. 10.	None.	June 1–20; Aug. 1–10; 21–31; Sept. 11–20.	July 11–Oct. 10.	June 11–20; July 1–Sept. 10; Sept. 21–Oct. 20.

[b] Danger periods A are the periods during which one or more than one fire occurs in 10 days. Danger periods B are the periods within which three or more fires occur in 10 days, or two fires or more a week.

TABLE XIII.—*Average number of general risk fires per year, per million acres, by 10-day periods*—Continued

REGION 17—SOUTHERN CALIFORNIA

Periods	Number of fires, by forest types				
	Western yellow and Jeffrey pines	Fir and pine slopes	Hardwood bottoms	Chaparral	Grass and sage [d]
Jan. 1–10	0.6			0.2	
11–20					5.0
21–31				.1	
Feb. 1–10				.1	
11–20				.1	
21–28/29				.3	
Mar. 1–10					
11–20				.1	
21–31			1.4	.1	5.0
Apr. 1–10				.1	
11–20	0.6			.1	
21–30				.2	
May 1–10		1.8		.3	5.0
11–20	.6		2.8	.1	
21–31	2.4		1.4	.2	10.0
June 1–10	1.2		2.8	.2	5.0
11–20	1.8		7.0	.9	45.0
21–30	2.4	5.4	12.6	.8	25.0
July 1–10	1.8	1.8	14.0	1.5	20.0
11–20	5.4	1.8	5.6	1.5	15.0
21–31	6.0	3.6	2.8	3.2	50.0
Aug. 1–10	10.8	5.4	9.8	2.6	5.0
11–20	6.0	5.4	23.8	2.7	15.0
21–31	9.0	18.0	21.0	2.8	20.0
Sept. 1–10	4.8	12.6	22.4	1.7	25.0
11–20	7.8	7.2	5.6	2.0	20.0
21–30	1.8	1.8	1.4	2.0	5.0
Oct. 1–10	1.8		1.4	1.0	15.0
11–20	.6		2.8	2.1	15.0
21–31	1.8	1.8	4.2	1.0	25.0
Nov. 1–10	1.2		2.8	.8	20.0
11–20	1.2	3.6	2.8	.7	10.0
21–30	1.2		1.4	1.3	5.0
Dec. 1–10				.4	
11–20				.1	
21–31				.1	5.0
Danger periods A [b]	May 21–Oct. 10; Oct. 21–Nov 30.	May 1–10; June 21–Sept. 30; Oct. 21–31; Nov. 11–20.	Mar. 21–31; May 11–Nov. 30.	July 1–Oct. 31; Nov. 21–30	Jan. 11–20; Mar. 21–31; May 1–Nov. 30; Dec. 21–31.
Danger periods B [b]	July 11–Sept. 20.	June 21–30; July 21–Sept. 20; Nov. 11–20.	June 11–Sept. 20; Oct. 21–31.	July 21–31.	Same as A

[b] Danger periods A are the periods during which one or more than one fire occurs in 10 days. Danger periods B are the periods within which three or more fires occur in 10 days, or two fires or more a week.
[d] Data on area very unsatisfactory, figures probably too high.

TABLE XIII.—*Average number of general risk fires per year, per million acres, by 10-day periods*—Continued

REGION 19—SOUTHWESTERN COLORADO AND NORTHERN NEW MEXICO [e]

Period	Number of fires, by forest types			
	Western yellow pine, Douglas fir, Engelmann spruce	Lodgepole pine	Pinon-juniper	Grass, brush, sage, and aspen
Mar. 1–10			0.4	
11–20				
21–31				
Apr. 1–10				
11–20				
21–30	0.2			
May 1–10	.2		.4	
11–20	.3		.7	0.3
21–31	.7			
June 1–10	.8		.7	.1
11–20	.4			.1
21–30	.8			.2
July 1–10	.6	0.9	.7	.1
11–20	.6			
21–31	.1			.1
Aug. 1–10	.2			.1
11–20	.5			.1
21–31	.5		.4	
Sept. 1–10	.1			
11–20	.1			
21–30	.2			.1
Oct. 1–10				.1
11–20	.2			
21–31	.4			.4
Nov. 1–10				
11–20	.1			.1
21–30	.3			.1

REGION 21—LAKE STATES [f]

Period	Number of fires, by forest types				
	Eastern white and red pines	Jack pine	Hardwoods	Tamarack and balsam	Open
Apr. 1–10	1.2				
11–20	2.5	1.5			6.7
21–30	13.7	3.7			13.3
May 1–10	3.7	.7			20.0
11–20	8.7	3.0	1.1		6.7
21–31	2.5	2.2	1.1		
June 1–10	5.0	1.1	4.3		
11–20	2.5	1.1	2.2		
21–30	1.2	1.5	1.1		6.7
July 1–10	1.2	.7	1.1		6.7
11–20	5.0	1.8	1.1		6.7
21–31	1.2				
Aug. 1–10		1.8			
11–20		.7		1.0	
21–31	1.2				6.7
Sept. 1–10	1.2	.4			6.7
11–20				1.0	
21–30					
Oct. 1–10		.7			6.7
11–20					
21–31		.4			
Danger periods A [b]	Apr. 1–July 31; Aug. 21–Sept. 10.	Apr. 11–30; May 11–June 30; July 11–20; Aug. 1–10.	May 11–July 20.	Aug. 11–20; Sept. 11–20.	Apr. 11–May 20; June 21–July 20; Aug. 21–Sept. 10; Oct. 1–10.
Danger periods B [b]	Apr. 21–May 20; June 1–10; July 11–20.	Apr. 21–30; May 11–20.	June 1–10.	None.	Same as A.

[b] Danger periods A are the periods during which one or more than one fire occurs in 10 days. Danger periods B are the periods within which three or more fires occur in 10 days, or two fires or more a week.

[e] No danger periods occurred in this region; that is to say, the average per 10 days was always less than one fire.

[f] Data on areas of all types very unsatisfactory; figures for numbers of fires in "open" probably much too high.

THE USE OF LIABILITY RATINGS IN FIRE PLANS

It is realized that the figures given in Tables VI to XIII are based on such incomplete data in many cases, perhaps in all, that they can not be used as absolute guides in allotting funds for primary protection. It does seem reasonable to believe, however, that figures worked out in this way can be so used, as soon as sufficient data accumulate to afford a basis for reliable figures on spread of fires, on suppression costs, and on the damage done in different types. It will also be desirable, perhaps, to have a more detailed classification of fires based not only on mere segregation by types, but also according to differences in the age of the stands, differences in quality of sites, and differences in characteristics with respect to inflammability.

Meanwhile, the figures given here may serve as valuable indicators in planning protection, provided they are not relied upon to too great an extent. In the first place, as fire plans for each of the national forests are worked out, showing the locations and areas of the different forest types classified according to the hour control now in effect, and ratings are made by the use of the tables, great differences in liabilities between different forests will undoubtedly appear. It will then be proper to examine more closely those forests whose liability is rated especially high and extremely low, to see whether or not more protection should be given the former.

Then, if the ratings could be relied upon absolutely, the justification of a suggested increase or decrease in protection could be determined by weighing its cost against the reduction or increase in total liability effected by such modification of the protection organization. Ratings based on the present data are not good enough to decide such questions, but should at any rate be suggestive.

A point which should be borne in mind is that it may not always be necessary to increase expenditures in order to increase the intensity of protection or to reduce the hour control. This may be accomplished on any forest unit in other ways, such as changing the distribution of personnel so as to locate men nearest to where the greatest number of fires will start, or nearest to where fires may be expected to spread most rapidly or be most destructive or costly to control, such as slashings, for instance. Nor do increased protection expenditures necessarily mean increased personnel, but the expenditure may be made in such a way as to reduce the hazard, by isolating special risks, or by removing especially hazardous conditions, such as logging slash, windfalls, or snags, or by improving communication.

MINIMUM REQUIREMENTS

It is believed that one exception should be made to the general principle of weighing costs against liabilities; that is, except in a very few places where it is certain that fires can be left without danger, enough protection should be provided during the danger season so that it will be possible to reach any part of every forest unit within 12 hours after a fire is discovered. The reason for this is that the law of averages is less dependable for longer elapsed periods, and even though averages may show comparatively low liabilities, it is more than likely that a considerable proportion of fires left for longer periods may do a great deal of damage or may prove very costly to control, or that they will spread from areas of low liability to areas where damage and costs will be much greater. A large proportion of the worst fires that have occurred on the national forests burned for more than 12 hours before they were attacked, and a considerable part of the total fire loss has been caused by such fires. For instance, nearly half of the total timber area burned during the five years studied, when the protective organization was not as well developed as it has subsequently become, is shown by the available records of elapsed time to have been burned over by fires which were not attacked until 12 hours or more after their discovery. (Tables XIV, XV, and XVI.)

TABLE XIV.—*Comparison of areas on which fires were attacked within 12 hours of discovery and those on which attack was later*

Region	Acreage of timber fires [a] by time of attack				Acreage of woodland and open fires by time of attack			
	Attack within 12 hours	Attack after 12 hours	Total burned	Percentage after 12 hours	Attack within 12 hours	Attack after 12 hours	Total burned	Per centage after 12 hours
	Acres	*Acres*	*Acres*	*Per cent*	*Acres*	*Acres*	*Acres*	*Per cent*
1	3,975	94	4,069	2	788	10	798	1
2	13,316	7,659	20,975	37	600	0	600	0
3	8,837	5,386	14,223	38	73	83	156	53
4	8,871	22,655	31,526	72	4,160	4,940	9,100	54
5	8,272	15,724	23,996	66				
6	17,477	7,154	24,631	29	22,274	7,573	29,847	25
7	6,940	12,168	19,108	64	11,295	0	11,295	0
8	8,961	27,264	36,225	75	2,948	4,600	7,548	61
9	5,901	813	6,714	12	3,894	161	4,055	4
10	6,083	1,471	7,554	19	12,438	7,968	20,406	39
11	26,657	827	27,484	3	2,506	200	2,706	7
12	1,484	0	1,484	0	96	20	116	17
13	2,602	451	3,053	15	1,566	361	1,927	19
14	21	80	101	79	1,070	1,282	2,352	54
15	487	153	640	24	12,706	60	12,766	0
16	29,084	4,565	33,649	14	67,567	10,281	77,848	13
17	6,228	590	6,818	9	147,539	6,617	154,156	4
18	17,294	32,090	49,384	65	8,578	87	8,665	1
19	3,058	648	3,706	17	2,287	0	2,287	0
20	8,514	670	9,184	7	8,893	555	9,448	6
21	[b]	[b]	[b]	[b]	66,593	15,149	81,742	19
Total	184,062	140,462	324,524	43	377,871	59,947	437,818	14

[a] Including subalpine type.

[b] Included in open.

TABLE XV.—*Number of fires by elapsed time groups, for general risk fires in all types*

Region	Total number of fires	Fires by hours elapsed from discovery to start of suppression work												
		Less than 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 15	15 to 20	More than 20
1	42	15	9	2	2	2	1		1	2	2	2	2	2
2	337	104	58	17	17	24	14	6	12	13	10	16	19	27
3	588	174	62	47	17	19	11	9	19	23	12	68	44	83
4	330	197	29	15	8	4	5	4	7	4	7	18	13	19
5	83	31	4	6	2		4	2	1	4	1	8	8	12
6	1,499	447	251	183	112	75	51	58	38	44	24	106	56	54
7	828	285	129	75	41	50	33	20	16	15	23	61	47	33
8	465	130	57	45	36	20	17	14	18	6	19	35	31	37
9	116	51	19	8	7	4	4		3	3	3	3	7	4
10	131	51	16	7	16	6	6	4	3	1	1	8	3	9
11	434	211	90	47	21	15	9	10	8	2	2	12	6	1
12	108	71	9	6	6	3	3	2	1	2	1	2	2	
13	108	56	19	6	8	3	1	2	4	1	1	2	1	4
14	25	11	6	2	2			1				1		2
15	73	27	12	12	3	4	2	1	3	1	4	1	1	2
16	1,385	669	223	135	79	52	20	25	15	17	20	77	27	26
17	745	557	78	22	21	18	6	9	6	5	4	10	3	6
18	1,096	496	154	129	85	52	27	23	17	10	11	38	30	24
19	235	114	40	22	18	10	5	3	4	1	3	6	5	4
20	197	76	43	17	16	8	9	4	1	4	1	7	4	7
21	149	105	13	8	9	1			1	1		5	3	3
Total	[a]8,974	3,878	1,321	811	526	370	228	197	178	159	149	486	312	359
Per cent	100	43.2	14.7	9.0	5.9	4.1	2.5	2.2	2.0	1.8	1.7	5.4	3.5	4.0

[a] Totals of Tables XV and XVI do not agree with Table I, because this table includes most of the fires on private land in and adjacent to the forests, on which data were available. On the other hand, Table I includes some fires not included here, because elapsed times were not given.

TABLE XVI.—*Number of fires by elapsed time groups, for special risk fires in all types*

Region	Total number of fires	Fires by hours elapsed from discovery to start of suppression work												
		Less than 1	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8	8 to 9	9 to 10	10 to 15	15 to 20	More than 20
1	115	108	3	2	1							1		
2	337	291	24	3	4	2	1	1	2	1	4	1		3
3	202	153	20	6	5	1	3	2			2	7	2	1
4	42	22	6	2	1	2		3	2			2	1	1
5	24	17			1		2					1	1	2
6	82	66	8	2	2	1				1			2	
7	53	39	9	2	2	1								
8	24	17	3		2	1	1							
9	33	24	7	1		1								
10	33	14	4	3	2	1	1				2	3	1	2
11	175	131	25	9	3	2	2	1		1		1		
12	148	120	15	5	2	1	1		1		1	2		
13	91	62	16	7								2	3	1
14	8	4		1				1		1				1
15	12	5	2	2	1	2								
16	214	155	44	6	1	1	3		1			1		2
17	113	86	15	2	3		1	1	2	1	1	1		
18	155	138	13	1			1		1			1		
19	119	71	29	8	4	2		2		1		1		1
20	17	7	4	3	2									1
21	180	151	15	5	2	1		1	1		2	2		
Total [a]	2,177	1,681	262	70	38	19	16	12	10	6	12	26	10	15
Per cent	100	77.2	12.0	3.2	1.7	0.9	0.7	0.6	0.5	0.3	0.6	1.2	0.5	0.7

[a] See note (a), Table XV.

PRIVATE LANDS

For purposes of rating liabilities, no consideration has been given to values on private lands within or adjacent to forest boundaries, because the cost of protecting such values should be met by the owners. It may in some cases be desirable to protect timber values on private lands, because of the possibility of the land being acquired later by the public, through exchange or in some other way. In such cases, arrangements should be made whereby the owner pays the cost of protection either now or at the time when the land is transferred.

In computing special liabilities for any forest units, due allowance should of course be made for special risk fires originating on adjacent or included lands which if not controlled may spread to the protected lands. Fires starting on a railroad right of way running through a forest, for instance, are as much a source of danger to the forest as if the right of way were owned by the public. Where, however, the right of way is so isolated by fire lines or otherwise that no fires ever have escaped from it on to the protected lands, fires occurring on the railroad land would not be counted in computing the liability.

FIRE PLAN RECONNAISSANCE

To apply the method of rating liabilities outlined in the preceding pages, or any other method, for that matter, it will be necessary to make some kind of a survey of the lands and resources that are to be protected. For a preliminary rating, this can be done in a rather extensive way, without a great amount of detailed field work, but such a rating should be followed, eventually, by a more accurate and detailed one based upon an intensive survey. In the meantime, more accurate and complete records should be kept of all fires that occur, in order to afford a better basis for rating liabilities.

DATA TO BE OBTAINED

The survey, whether extensive or intensive, should result in the following information for each forest and protection unit (or ranger district):

1. A map, showing the location and extent of all areas of each class of risk, together with the hour control effective for each area, under the existing conditions. The amount of detail used in classification of risks will depend upon the intensity of the survey.

2. Statistical data regarding the areas subject to risk, classified as shown on the map. These data may be represented in tabular form, somewhat as follows:

A.—AREAS SUBJECT TO GENERAL RISK

Unit	Forest type	Age class	Risk class	Hour control			Quantity and value of timber and young growth		General liability factor	Total general liability
				Less than hour (acres)	1 to 2 hours (acres)	Etc. (acres)	Total	Per acre		

"General liability factors" are the factors for total liability per 1,000 acres, as already given in Table XII. With the data so far available there will be one uniform factor for each type in a given region, regardless of its age or risk class, but varying with hour control. When more detailed ratings can be made, it will be desirable to use different liability factors for stands of different ages and different relative risk. It will also be desirable to take into account the differences in quantities and values at stake, possibly by expressing liability of loss in terms of percentage of total values, instead of directly in dollars.

The preliminary reconnaissance need not show age classes or risk classes, since we have not the data necessary to rate them separately. It is obvious, however, that both costs of suppression and amounts of damage will vary rather widely with differences in age or risk class within a single type, and separate ratings should be made as soon as fire records with the necessary basic information accumulate. It is desirable to have information regarding the distribution of age classes and risk classes for use in planning protection, even though we can not yet rate liabilities in such detail. The classification as to hour control should be based on what is reasonably possible with the existing or proposed protective organization, taking into consideration location of personnel and means and speed of travel.

3. Special information should be given regarding areas of high liability, whether due to probability of occurrence of fires, to probability of rapid spread and of difficulty in suppression, or to probability of heavy damage because of the size of the area likely to burn over, or because of high destructible values. Such information should describe the reasons for the high liability, and, if possible, suggest means of reducing it.

SPECIFICATIONS FOR CLASSIFYING RISKS

The following specifications are suggested as a basis for the classification of areas indicated in the maps and tables described above. The limit of subdivision should be approximately 40 acres for the intensive survey, or 160 acres for an extensive one; or, in other words, no area should be distinguished on the map, or counted in preparing the tables, unless it is at least 40 or 160 acres, respectively, in extent. Smaller areas should be thrown with the neighboring ones. Exceptions to this rule may be made in the case of smaller areas of especially great liability.

B.—AREAS SUBJECT TO SPECIAL RISKS

Number of fires per year per unit area of the type, for the given unit and cause [a]	Special liability factor	Total special liability (for this cause)

[a] The same data for each kind of special risk separately, as in A, except for the last two columns, for which should be substituted the last two columns of B.

FOREST TYPES.—To be classified on the basis of present cover, because that is what is being protected and what determines the hazard and liability. All areas which are fairly satisfactorily stocked with tree growth, no matter how small, should be classed with the

type represented by those trees, and not with the type represented by the possibly more obvious cover, such as brush. In other words, brushfields which have a good stand of tree reproduction beneath the brush cover should be classed with the proper timber type, and not with "brush." In case of two-storied types, as conifers under aspen in some parts of the Great Basin region, the cover should be classed according to the species of chief economic or silvicultural importance. For instance, if such a stand is to be handled as an aspen forest, the conifers may be considered as underbrush, and the type be called "aspen." But if the conifers are to grow to maturity and become the chief crop, and the aspen represents only a temporary phase of the development of a conifer stand, then the cover should be designated as belonging to the proper conifer type. Strictly speaking, there should be classed as "subalpine" only the strictly noncommercial scrubby or scattered high altitude stands, although the ratings as developed in this study undoubtedly included some merchantable fir and spruce and probably some lodgepole pine stands as subalpine.

In general, the definitions of the different types will be about the same as those prescribed for use in timber surveys. In some cases, however, two or more of these types have been grouped together in the present study, and some of these groups may be allowed to stand even in working out more detailed ratings in the future. Others should be separated if possible. Such are the aspen type of the Central Rocky Mountains, now combined with other types; the Engelmann spruce and subalpine types, now combined in several regions; and the brush, grass, and woodland types, now thrown together in a number of cases. In some instances, where a type occurs over a limited area within a region, it has been combined with other types. Thus the limited areas of western yellow pine in the Northern Rocky Mountain region should be thrown in with the Douglas fir or lodgepole pine types.

AGE CLASSES.—Classification as to age should be based on the age of the major part of the stand; for instance, a very scattered stand of old seed trees, over a fairly well-stocked stand of reproduction, would be classed as reproduction; a stand composed of trees of several age classes, but with a large preponderance of mature trees, would be classed as mature. Not more than five age-classes should be recognized. These are:

1. Reproduction	Trees up to 4 inches d. b. h.
2. Small poles	Trees between 4 and 7 inches d. b. h.
3. Large poles	Trees between 8 and 11 inches d. b. h.
4. Young merchantable.	Trees 12 inches or more in d. b. h., up to the rotation age, or the age generally considered as representing maturity.
5. Mature and overmature.	

In addition to these five classes, a sixth class of stand should be recognized, viz: All-aged, where practically all ages are present in approximately equivalent proportions.

RISK CLASSES.—Each stand, after being classified according to type and age class, should be further classified according to the degree of risk involved. "Risk" is used here in the sense of inflammability and controllability, independent of the probability of fires starting or of the presence or absence of a protective organization. For the purpose of rating liabilities, three risk classes should be recognized, based on the susceptibility of the stand to fire. This susceptibility is determined by the fire resistance or inflammability of the component species and of the ground cover, and to some extent by topographic conditions, which favor or hinder rapid spread and destructiveness of fires, and make control work difficult or easy. These classes may be designated as low risk, average risk, and high risk, and should represent the relative risks as between stands of the same type and age class, but not between stands of different types. A stand of western yellow pine classed as "high risk" might not represent as great damage or cost as a "low risk" stand of western white pine, but it would represent a risk greater than the average for the yellow pine stands in the region concerned. Brief tentative specifications for the different risk classes follow.

LOW RISK

Reproduction.—Young trees scattered as individuals or in patches, with comparatively little brush or litter, or where the cover is grazed fairly close before the fire season, or where the inflammable ground cover as a whole—including tree reproduction, grass, weeds, brush, and litter—is not continuous, but is broken by numerous openings or patches of bare soil, rock, or less inflammable vegetation, (such as bear clover). On sheltered flats or moist bottoms, the cover may be more continuous.

Pole stands.—For larger poles, stands with comparatively little undergrowth or dead and down material, and with boles fairly clear of dead branches or moss. For smaller sizes of poles, broken stands with noninflammable openings. For all sizes, stands on sheltered flats and in moist situations.

Merchantable stands.—Comparatively open stands with clear boles, little undergrowth except grass and weeds, or tree reproduction less than 1 foot high, with few standing snags and little litter or débris. Trees not badly scarred at their bases, nor covered with dry moss or pitch. In mixed types, stands composed largely of the more fire resistant species of the mixture. In all-aged stands, those where older trees largely predominate. No deep continuous layer of duff. Stands on sheltered flats and on moist sites which in other situations might fall in a more hazardous class.

AVERAGE RISK

Reproduction.—Stands of fair density, with a fairly continuous cover of light herbage and scattered brush, with only a moderate amount of scattered débris, or with considerable litter entirely shaded and kept from drying out by a dense crown cover. Such stands on moist flats might be classed as low risk, and on steep slopes exposed to drying winds as high risk.

Pole stands.—Larger sizes, with some undergrowth and débris, or with average amount of dry lower branches. Smaller sizes, with comparatively little, or only patchy, inflammable ground cover.

Merchantable stands.—Stands with a fair amount of undergrowth, including tree reproduction, and with more or less débris, scattered standing snags, and more moss, low crowns, or dry lower branches. Stands with average proportions of the more inflammable species.

HIGH RISK

Reproduction.—Either open or dense stands, with heavy grass, dry during the fire season, or a continuous cover of brush and débris to carry fire. Stands on steep slopes and other sites exposed to drying winds. An extreme example of a "high risk" stand of reproduction or poles is found in the "jack-straw" burns common in many regions.

Pole stands.—The larger sizes, where there are large amounts of inflammable ground cover and débris, moss on stems, low inflammable crowns, standing snags, or on steep exposed sites. In mixed stands those with larger proportions of the less resistant species. The smaller poles, where there is a continuous cover of brush or inflammable débris, even if not especially great in quantity. Stands on steep slopes or most exposed situations, which on other sites might fall into the "average risk" class.

Merchantable stands.—Stands with large amounts of inflammable undergrowth or débris (such as logging slash), large numbers of standing snags, bases of trees badly fire-scarred, boles covered with dry branches or much dry moss or resinous bark. Stands with somewhat less inflammable material, where especially exposed to drying winds or on steep slopes. In mixed stands, those where the least resistant species are represented in large numbers; in all aged stands, those with a large proportion of the younger ages. Stands with a deep layer of duff or peat which dries out during the fire season.

DESTRUCTIBLE VALUES

Values should be tabulated as indicated, for individual stands. These values represent what would be lost in case of total destruction by fire, and include values of timber, both merchantable and young growth, of the forest capital (not including soil productivity), where that is involved, and of intangibles such as watershed protection. Forage value is omitted, unless it can be considered to be included in the figures given for the other values, for the reason already mentioned, viz, that destructible value of forage is generally so insignificant in comparison with the other values as to be less than the probable error in estimating the others. For the sake of simplifying calculations, therefore, it is left out.

In order that such values can be easily gotten at, and to insure that the values given shall be comparable as between different forest units and between different regions, and also in order that figures on damage during a series of years may be computed on the same basis and may therefore be possible of comparison—which is not the case with the records hitherto collected—it seems extremely desirable to establish standards, to be used uniformly, without the necessity of leaving very much to the individual judgments or guesses of reporting officers.

These standards should be as simple as is consistent with the purpose for which they are to be used, namely, to show relative values and relative damages as between stands of different species, of different ages, and in different regions. Moreover, they should be in such form as to enable the field men to work the values out without mathematical formulae. With these ideas in mind, standard values were worked out as outlined below.

VALUES OF MERCHANTABLE TIMBER

Merchantable timber, i.e., timber of merchantable size in "young merchantable," "mature," and "all-age" stands, should be valued on the basis of its species and volume, at fixed stumpage rates. For reasons already discussed, it seems advisable to use uniform rates for one species throughout a given region The values suggested have been given in Table VIII. Such scattered trees of merchantable size as may be found in "reproduction" and "pole" stands should not be given a timber value, because they generally would not be utilized for timber. No additional allowance is made for the capital value of merchantable stands, because, in general, natural reproduction will follow the destruction of such stands, if further fires and grazing are kept out. No value will be put on the timber, as such, in scrubby high-altitude subalpine stands that never will be utilized for timber production. Their value consists entirely of the intangible values for watershed protection and the like, and for mature stands will be the same as given in Table XVII for "large poles."

VALUES OF YOUNG GROWTH

The timber value of young growth depends upon its species and the stage of development which it has reached. This value is the value of the accrued net return on the capital value of the forest, for a number of years equal to the economic age of the stand. For natural stands, such as practically all of those on the national forests, it can be expressed by the formula:

$$V = Y \times \frac{1.0p^m - 1}{1.0p^n - 1}$$

Here Y is the value of the final crop (for the sake of simplicity no allowance is made for intermediate returns from thinnings), $.0p$ is 3 per cent, m is the economic age of the stand, and n is the number of years in the rotation.

The value of Y depends upon the stumpage value per thousand board feet and the amount of timber that will be produced during a rotation. For the purpose of establishing standard values for young growth, arbitrary rotations and yields were used, with the stumpage rates given in Table VIII. Because we know very little about what rotations will actually be used for stands now below merchantable size, it seemed advisable for the present purpose to use a uniform rotation period of 100 years, regardless of forest type, in the regions where growth is moderately fast (regions 2, 3, 4, 5, 6, 7, 8, 16, and 17), and 150 years where it is slower (regions 1, 9, 10, 11, 12, 13, 14, 15, 18, 19, and 20). For the Lake States (region 21) a 70-year rotation was used.

In order that the field men may not have to estimate the ages of the stands, and to reduce the division into age classes to the simplest practicable terms, only three age classes of young growth are recognized, and these are expressed in terms of size, rather than of age. They are: Reproduction (stands below 4 inches d. b. h.); small poles (4 to 7 inches d. b. h.); and large poles (8 to 11 inches d. b. h.). In stands classed as "all-aged," young growth of all sizes will be lumped together. For computing values by the formula, the average ages of these size-classes were assumed to be: For 150-year rotation, 20, 40, and 70 years, respectively; for 100-year rotation, 15, 30, and 50 years; and for 70-year rotation, 10, 20, and 35 years.

Besides the timber, or product, value of young stands, there is their value as part of the forest capital. The destructible part of this value (aside from soil productivity, which will not be considered) is the cost of establishment. That is to say, when a new stand has been established on the burned area, the forest capital (but not the accumulated product) has been restored. If a destroyed stand is quickly replaced by natural reproduction, it is considered that no capital loss has been suffered; but where natural restocking does not follow, the capital loss, equal to cost of replanting, must be added to the product loss. Standard costs of planting have been given in Table IX. For the sake of simplicity and uniformity, it has been assumed that stands of young growth covering less than 10 acres, and also young growth of any area under merchantable stands or scattered through all-aged stands, will be replaced by seeding from the sides or from above if destroyed by fire, and that areas greater than 10 acres (except where mixed with older timber) will not restock naturally. Burns smaller than 10 acres, within more extensive stands of young growth, can not be depended upon to restock naturally within a reasonably short period; therefore damage in such cases will include the capital loss. Exceptions to the above assumption are: the western yellow pine in regions 14, 15, 18, 19, 20, where it was assumed that only one-half of the destroyed area will restock even in stands smaller than 10 acres; Douglas fir in the same regions, where it was assumed that only two-thirds of the destroyed area will restock in stands smaller than 10 acres; the woodland types in all regions, where only one-half will restock in stands under 10 acres in extent; lodgepole pine and jack pine stands of the "large pole" class, where it was assumed that half the burns will restock naturally even in stands larger than 10 acres; and the hardwood and aspen types in all regions, which will restock entirely, even on large burns.

INTANGIBLE VALUES

There appear to be no data upon which to base valuations of watershed protection, recreation values, or other similarly intangible benefits due to the presence of a forest cover, or to estimate what part of such values might be destroyed by a fire. It seems fairly reasonable to suppose that in most cases where reproduction will follow naturally almost immediately after the burn, the damage to such values is comparatively small; where such restocking will not take place, the damage estimates

already allow for the cost of restoring a stand by planting, which is probably considerably greater than the actual intangible loss. No additional value, therefore, has been allowed for "intangibles," except in the case of brushland and grassland, and subalpine areas that do not produce merchantable timber, and the southern California hardwood bottomlands type, that has small commercial value and a very great intangible value. For these types, arbitrary intangible values were assumed. Except in the case of the Southern California stream bottom type, it was also assumed that very little or no damage would be done to the intangible values by fires covering less than 40 acres. In this type, even small fires, if they destroy the cover, do considerable damage, even though natural restocking quickly follows, and the damage where stands of mature trees are destroyed is at least as great as for younger stands, regardless of the timber value.

TOTAL VALUES

The standard total destructible values per fully stocked acre of young growth of the different types and in the several regions have been given in Table XVII. For the use of field officers within a given region, these values are not as complicated as they may appear here, because any one officer will have to consider only the figures that apply to his particular region, and to the types which are found on his particular district.

TABLE XVII.—*Standard total destructible values of young growth*

Type	Region	Destructible value per well-stocked acre						
		Reproduction		Small poles		Large poles		Reproduction and poles in all aged stands
		Areas under 10 acres	10 acres and over	Under 10 acres	10 acres and over	Under 10 acres	10 acres and over	
		Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
Yellow pine, including western yellow pine–sugar pine mixtures in California.	1,9,10,11	0.60	9.10	1.65	10.15	5.00	13.50	2.00
	2	1.25	8.25	3.15	10.15	7.40	14.40	2.70
	3	1.40	7.40	3.50	9.50	8.35	14.35	3.00
	4	1.55	11.55	3.90	13.90	9.30	19.30	3.30
	6	2.40	12.40	6.10	16.10	14.50	24.50	5.20
	7	1.65	11.65	4.25	14.25	10.00	20.00	3.60
	8	1.45	11.45	3.75	13.75	8.90	18.90	3.20
	12, 13	.45	12.45	1.20	13.20	3.65	15.65	1.50
	14, 15	7.75	15.25	8.20	15.70	9.60	17.10	8.30
	16	2.75	14.75	7.05	19.05	16.70	28.70	6.00
	17	9.05	16.55	11.40	18.90	16.80	24.30	10.80
	18, 19	8.00	15.50	8.85	16.35	11.65	19.15	9.25
	20	8.10	15.60	9.15	16.65	12.50	20.00	9.50
Douglas fir, including western larch mixtures in the northwest, lower slope mixture on west coast, and bigcone spruce slopes in southern California.	1, 12, 13	.20	10.20	.60	10.60	1.90	11.90	.75
	2	1.05	7.05	2.75	8.75	6.60	12.60	2.30
	3	1.40	9.40	3.50	11.50	8.35	16.35	3.00
	4	1.40	11.40	3.50	13.50	8.35	18.35	3.00
	5	2.75	10.25	7.00	14.50	16.70	24.20	6.00
	6	2.55	10.05	6.55	14.05	15.50	23.00	5.60
	7, 8	.85	10.85	2.20	12.20	6.00	16.00	1.90
	9	.25	10.25	.70	10.70	2.20	12.20	.90
	10	.30	10.30	.80	10.80	2.50	12.50	1.00
	14, 15	5.30	15.30	5.80	15.80	7.50	17.50	6.00
	16	1.40	11.40	3.50	13.50	8.35	18.35	3.00
	17	10.90	20.90	12.35	22.35	15.60	25.60	12.00
	18, 19, 20	4.40	12.40	5.00	13.00	7.15	15.15	5.25
Lodgepole pine, including knobcone pine in California.	1, 12	.35	10.35	.95	10.95	2.95	7.95	1.20
	2, 16	.90	8.90	2.35	10.35	5.60	9.60	2.00
	3, 6	1.55	9.55	3.90	11.90	9.30	13.30	3.30
	4	1.05	11.05	2.75	12.75	6.60	11.60	2.30
	5	1.20	9.20	2.90	10.90	7.00	11.00	2.50
	7	1.40	11.40	3.40	13.40	8.15	13.15	2.90
	8	1.25	11.25	3.15	13.15	7.40	12.40	2.70
	9	.30	10.30	.85	10.85	2.70	7.70	1.10
	10, 13, 14, 15, 19	.40	10.40	1.05	11.05	3.30	8.30	1.30

TABLE XVII.—*Standard total destructible values of young growth*—Continued

Type	Region	Destructible value per well-stocked acre						
		Reproduction		Small poles		Large poles		Reproduction and poles in all aged stands
		Areas under 10 acres	10 acres and over	Under 10 acres	10 acres and over	Under 10 acres	10 acres and over	
		Dolls.	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*	*Dolls.*
Spruce and fir (not subalpine), including cedars and hemlock when not included in white pine or Douglas fir types.	1, 9	0.20	6.70	0.50	7.00	1.50	8.00	0.60
	2	.90	6.90	2.35	8.35	5.60	11.60	2.00
	3	1.40	7.40	3.50	9.50	8.35	14.35	3.00
	4	1.20	8.70	2.90	10.40	7.00	14.50	2.50
	5	1.25	8.75	3.15	10.65	7.40	14.90	2.70
	6	.90	8.40	2.35	9.85	5.60	13.10	2.00
	7	.70	8.20	1.75	9.25	4.20	11.70	1.50
	8	.50	8.00	1.25	8.75	3.00	10.50	1.10
	10	.30	6.80	.80	7.30	2.50	9.00	1.00
	12	.25	10.25	.70	10.70	2.20	12.20	.90
	13, 15	.20	10.20	.60	10.60	1.90	11.90	.75
	14	.25	10.25	.65	10.65	2.00	12.00	.80
	16	1.40	9.40	3.50	11.50	8.35	16.35	3.00
	18, 19, 20	.30	10.30	.90	10.90	2.85	12.85	1.10
	21	2.00	8.00	4.65	10.65	10.50	16.50	4.00
Western white pine	2	3.50	8.50	8.90	13.90	21.10	26.10	7.60
	3	4.50	10.50	11.45	17.45	27.15	33.15	9.75
Eastern white pine and Norway pine.	21	10.20	16.20	26.20	32.20	59.00	65.00	22.50
Jack pine	21	1.50	11.50	3.50	13.50	7.85	12.85	3.00
Hardwoods	17	20.00	20.00	20.00	20.00	20.00	20.00	5.00
	21	2.50	2.50	5.80	5.80	13.10	13.10	5.00
Subalpine, noncommercial high altitude type.	1, 9, 10, 12, 13, 14, 15, 18, 19, 20.	.....	10.10	.....	10.50	.....	11.00	.25
	4, 5, 6, 7, 8, 16.	.....	8.10	.....	8.50	.....	9.00	.25
	2, 3	.....	6.10	.....	6.50	.....	7.00	.25
	17	.....	15.10	.....	15.50	.....	16.00	.25
Aspen	All regions where of commercial value.	.60	.60	1.60	1.60	3.70	3.70	1.30
Woodland. Includes piñon-juniper, digger pine-oak, and similar types.	4, 7, 8	2.60	5.10	2.80	5.30	3.20	5.70	2.75
	6, 12, 13, 14, 15, 17, 18, 19, 20.	2.75	5.25	3.10	5.60	3.90	6.40	3.00
	16	2.95	5.45	3.70	6.20	5.30	7.80	3.50
Brush, not restocking with commercial species. Includes chaparral type and other brushfields.	1, 2, 3, 5, 9, 10, 11, 12, 13.	Uniform value $0.10 per acre (for areas greater than 40 acres).						
	4, 6, 7, 8, 16.	Uniform value $0.25 per acre (for areas greater than 40 acres).						
	14, 15, 18, 19.	Uniform value $0.50 per acre (for areas greater than 40 acres).						
	17	Uniform value $5.00 per acre (for areas greater than 40 acres).						
	20	Uniform value $2.00 per acre (for areas greater than 40 acres).						
Sagebrush and grassland	All regions.	Uniform value $0.05 per acre.						

FIRE RECORDS

To provide an accurate basis for future rating by the methods outlined in this report, or by any other scientific method, it is essential that accurate records be kept of all fires throughout the country. Since the value of such records varies directly with their completeness and accuracy—inaccurate records are but little more useful than none at all—it will be decidedly worth while to take considerable pains to see that they are made and kept in good shape. All reports on individual fires should be checked up by a competent supervisory officer to see that they give the information that is required to make them useful. For the purpose of rating hazards and liabilities, the reports for each protective organization should always give at least the following information; other data may be desired from time to time for administrative studies of various sorts:

1. Location of the fire.
2. Date and hour of the discovery of the fire (and of its start if known); of the start of work on it; when it was under control; when it was out.
3. Cause, in detail. For instance, if a camper fire, what kind of a camper—traveler, sheep-herder, campfire?
4. Cover. Forest type, age class, risk class.
5. Area burned, classified according to types, age, and risk classes, if more than one.
6. Destructible values on the burned area before the fire.
7. Losses—quantities (thousand feet by species, and fully stocked acres of young growth by types and age classes, if more than one) and values, according to standard figures.
8. Costs of suppression—itemized in such a way that that part of the cost chargeable to primary protection may be kept distinct from special fire-fighting costs.

In addition to the detailed individual reports on all fires, which may be transferred to tabulation sheets or punched cards for convenience in filing and future study, it is also desirable that sets of maps be kept up to date showing the character and values of the cover on the whole area, and the locations of all fires covered in the reports. Such maps should be on a fairly large scale, preferably one-half inch or one inch to the mile. The fire records should be made permanent, and those for any one organization should preferably be kept all together in one place.

ASCARIDIA LINEATA, A PARASITE OF CHICKENS IN THE UNITED STATES[1]

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INTRODUCTION

Heretofore it has been assumed that the large intestinal roundworm of chickens in the United States is *Ascaridia perspicillum*, a species described from the intestine of turkeys by Rudolphi in 1803 (*12*).[2] A recent study by the present writer of specimens of Ascaridia collected at various times from the intestine of chickens, in and around Washington, D. C., in New Jersey, Kansas, and in several other localities, has shown that the species in question does not conform to the description of *A. perspicillum* as given by various writers, but conforms in practically all respects to the description of another species, namely, *A. lineata*, which was described by Schneider in 1866 (*13*).

These two species have undoubtedly been confused in the past, partly owing to their close relationship, and partly because the tendency of most workers who are not systematists is to make host determinations of parasites. The fact that *A. perspicillum* is an earlier described species and that its type locality is Europe is probably largely responsible for the importance that has been assigned to it in textbooks on parasitology, whereas *A. lineata*, which was originally described from Brazil, has received but secondary consideration in the widely used textbooks on parasitology, nearly all of which have been written by European workers. As will be presently shown, *A. lineata* is not only more prevalent then *A. perspicillum* in the United States and in all probability in other parts of the world, but is also possibly the only species of Ascaridia parasitic in chickens in this country, the occurrence of *A. perspicillum* in American chickens not yet having been definitely established.

ASCARIDIA PERSPICILLUM (RUDOLPHI, 1803)

Rudolphi's description of *Ascaris perspicillum* is based on immature female specimens from the turkey, and, in common with specific diagnoses of a century ago, contains little that is of diagnostic value. According to Dujardin (*3*) *A. perspicillum* of Rudolphi is apparently identical with *Fusaria inflexa* of Zeder. Dujardin (*3*) states that the entries in the catalogue of the Vienna Museum, whose helminthological collections were studied by Rudolphi, contain no reference to *A. inflexa* from chickens, this species being recorded only from ducks. Dujardin also states that the catalogue in question contains but a single entry of *A. perspicillum* from the turkey.

Schneider (*13*), in his extensive monograph on nematodes, states that he examined one male and one female specimen of *Heterakis perspicillum* and found them to be identical with *H. inflexa*, of which he also examined specimens. In both cases the material examined appears to have been material studied by Rudolphi. Although Schneider was unable to make out the structure of the lips in the specimens labeled *Ascaris perspicillum*, he had no difficulty in making out the papillae on the tail of the male, which he found to correspond to those of *A. inflexa*. Since the papillae on the tail of the male are commonly regarded as the most important specific characters in the suckered roundworms (Heterakidae), it may be taken for granted that Schneider was correct in regarding *A. perspicillum* and *A. infleza* as identical.

Schneider figures 9 pairs of papillae on the tail of the male of *Heterakis inflexa* (fig. 1), arranged as follows: 3 pairs of ventral papillae arranged in a row on each side of the sucker, the most cephalad papillae being anterior to, and the third, or most caudal pair, being posterior to the sucker, whereas the middle pair corresponds in position approximately to the equator of the sucker. The next group consists of 4 pairs of papillae, of which 3 pairs are lateral and 1 pair is ventral, and finally, there are 2 pairs of lateral papillae near the tip of the tail.

[1] Received for publication June 30, 1924; issued June, 1925.

[2] Reference is made by number (italic) to "Literature cited," p. 772.

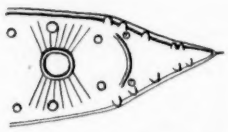

FIG. 1.—*Heterakis inflexa* (after Schneider, 1866)

The views expressed by Dujardin (*3*) and Schneider (*13*) as regards the specific indentity of *Ascaridia inflexa* and *A. perspicillum* have been generally accepted by helminthologists, including Railliet (*10*), who states that this species has 10 pairs of papillae, but makes no statement as to their arrangement, excepting that 3 pairs are preanal and 7 pairs are postanal. Railliet and Henry (*11*), in their paper on the classification of the Heterakidae, list *A. perspicillum* as being possibly identical with *A. inflexa*, a similar attitude of uncertainty being expressed by Skrjabin (*14*).

Recently *Ascaridia perspicillum* has been figured by Baylis and Daubney (*1*) (fig. 2) and by Smit (*15*) (fig. 3). According to the former, there are 10 pairs of papillae on the tail of the male, the first group consisting of 4 pairs of ventral papillae, instead of 3 pairs as figured by Schneider, the remaining papillae agreeing as to number and position with those of Schneider. Smit, on the other hand, while agreeing with Baylis and Daubney as to the number of papillae, shows a somewhat different mode of arrangement, since he figures 2 ventral and 3 lateral pairs of papillae in the second group, as compared with 3 pairs of lateral and only 1 pair of ventral as figured by Schneider and by Baylis and Daubney. The remaining papillae as figured by Smit correspond to those figured by Schneider.

The different conceptions as to the number and arrangement of the papillae of *Ascaridia perspicillum* may be summarized as follows:

	Schneider	Baylis and Daubney	Smit
Group 1	3 pairs of ventral papillae	4 pairs of ventral papillae	3 pairs of ventral papillae.
Group 2	3 pairs of lateral papillae	3 pairs of lateral papillae	3 pairs of lateral papillae.
	1 pair of ventral papillae	1 pair of ventral papillae	2 pairs of ventral papillae.
Group 3	2 pairs of lateral papillae	2 pairs of lateral papillae	2 pairs of lateral papillae.

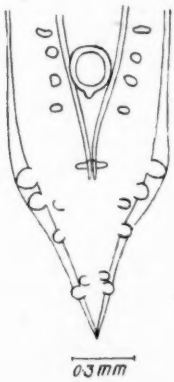

FIG. 2.—*Ascaridia perspicillum*. (After Baylis and Daubney, 1922)

Assuming that Schneider, Baylis and Daubney, and Smit were dealing with the same species, it will be seen from the comparison of their descriptions of the papillae that they all agree as to the presence of only two lateral papillae in the region of the tip of the tail, the number of ventral papillae in the anterior two groups showing variations. Whether the species in question (*As-*

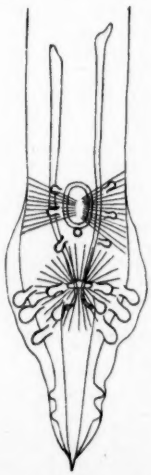

FIG. 3.—*Ascaridia perspicillum*. (After Smit, 1922)

caridia perspicillum) is variable with respect to the ventral papillae, or whether under the name *Ascaridia perspicillum* two or more species have been confused, must be left an open question. So far as concerns the arrangement of the papillae on the tail of the male in specimens of *Ascaridia* from chickens in the United States and from other localities that have been examined by the present writer, they do not correspond to any of the patterns described for *A. perspicillum*, but agree with that of another species, namely, *A. lineata*.

ASCARIDIA LINEATA (SCHNEIDER, 1866)

Schneider (*13*) describes *Heterakis lineata* from the intestine of the chicken from Brazil in the same paper in which he discusses the identity of *Heterakis perspicillum* and *H. inflexa*. Schneider differentiates *H. inflexa* (*H. perspicillum*) from *H. lineata* on the basis of the structure of the lips as well as on the basis of the number of papillae on the tail of the male. He states that *H. inflexa* has 3 dentigerous ridges on each lip, the first 2 being round and the third (most posterior) being quadrangular, whereas *H. lineata*, according to this writer, has only 2 dentigerous ridges, the second ridge being very small. As far as concerns the papillae on the tail of the male, Schneider figures 10 papillae for *H. lineata* (fig. 4), the last group of papillae in the region of the tip of the tail consisting of 3 pairs, 2 lateral and 1 ventral, as compared with only 2 pairs of lateral papillae in *H. inflexa*. The remaining papillae, according to Schneider's figure, correspond in number and position to those of *H. inflexa*.

FIG. 4.—*Heterakis lineata* (after Schneider, 1866)

Other records of the occurrence of *Ascaridia lineata* besides those given by the present writer are as follows:

Von Linstow (*7*) records and figures *Heterakis lineata* from the duck from Turkestan. The number and arrangement of the papillae as figured by Von Linstow correspond accurately with those of Schneider, although there are two discrepancies, namely, as regards the elongation of the first ventral papilla, which is figured as transversely flattened by Von Linstow (fig. 5), whereas Schneider figures it as spherical in shape. As regards the second lateral papilla, Von Linstow figures it as directed laterally, whereas Schneider figures it as directed ventrally.

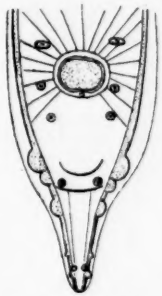

FIG. 5.—*Heterakis lineata* (after Von Linstow, 1883)

Von Linstow (*8*) records *Heterakis inflexa* from the chicken, but from his description of the papillae, in which 3 pairs are enumerated in the region of the tip of the tail, 2 being lateral and 1 ventral, it may be taken for granted that he was dealing with *Ascaridia lineata*.

Wolffhügel (*18*) records *Heterakis lineata* from Switzerland from the chicken and the duck, but he records *H. inflexa* (*Ascaridia perspicillum*) only from the grouse (*Tetrao urogallus*).

Travassos (*16*) records and figures *Ascaridia lineata* from chickens in Brazil, the type locality of this species. His drawing of the tail of the male (fig. 6) shows a perfect agreement with that of Von Linstow (fig. 5) as to number, arrangement, and direction of the papillae.

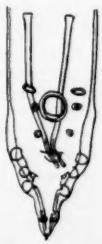

FIG. 6.—*Ascaridia lineata* (after Travassos, 1913)

Gedoelst (*4*) records *Ascaridia lineata* from the chicken in the Belgian Congo.

Boulenger (*2*) records and figures *Ascaridia lineata* from the chicken in Zanzibar on the basis of a single male specimen. His figure (fig. 7) agrees in all respects except one with that of Von Linstow and Travassos, the exception being the direction of the second lateral papilla, which is described as being turned ventrally, thus agreeing in this respect with Schneider's figure. Boulenger observes that these discrepancies are probably due to individual variations.

According to Boulenger (*2*) *Ascaridia hamia*, a species described by Lane (*5*) from the intestine of chickens in Bengal, India, is *Ascaridia lineata*, a view with which the present writer is in full agreement. Lane's figure and

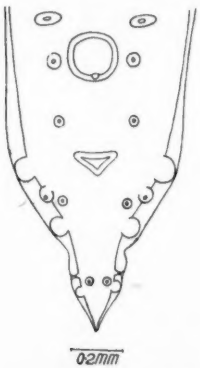

FIG. 7.—*Ascaridia lineata* (after Boulenger, 1923)

description of the papillae (fig. 8) show a perfect agreement with those of Schneider, Von Linstow, Travassos, and Boulenger, and although his description of the species as a whole shows some discrepancies as compared with the present writer's observations on *A. lineata*, these discrepancies can all be accounted for, as will be presently shown, on the basis of individual variation.

According to Travassos (*16*), *Heterakis brasiliensis* Magalhães, 1892 (*9*), is also a synonym of *Ascaridia lineata*. Magalhães' description is rather vague as regards the papillae on the tail of the male and does not agree with his figure in all respects. He states that the worm has 9 pairs of lateral papillae, but he actually enumerates 10 pairs and one accessory papilla. Certain of the papillae referred to by Magalhães as lateral are obviously ventral in position. The description that Magalhães gives of *H. brasiliensis* is too incomplete to permit any definite opinion as regards the status of that species.

In all of the records of the occurrence of *Ascaridia lineata* which have just been reviewed, excepting that of Schneider, no mention is made of *A. perspicillum* as a parasite occurring alone or in association with *A. lineata* in the same host species. This fact is of importance and indicates that when specimens of Ascaridia from chickens and related domestic birds have been actually studied morphologically they have been found to be *A. lineata*, which is apparently the common species of Ascaridia in domestic birds.

FIG. 8.—*Ascaridia hamia* (after Lane, 1914)

OBSERVATIONS ON ASCARIDIA LINEATA BY PRESENT WRITER

Observations on *Ascaridia lineata* by the present writer were made on material collected in the United States by various workers in this laboratory in the vicinity of Washington, D. C., as well as on material forwarded to this bureau for determination from several different localities. In addition to American material, specimens collected from chickens in the Philippine Islands and at Tonkin, Indo-China, were also studied. In material forwarded from Indo-China immature specimens of *A. lineata* from the goose (fig. 9) were identified, this host being new for this species of parasite.

In all specimens that have been examined, the number and arrangement of the papillae on the tail of the male correspond to those described by

various workers for *Ascaridia lineata*. The different variations as regards the first ventral and second lateral papillae which have been referred to elsewhere in this paper were also encountered. The number of papillae on the tail of the male was found to be 10, the first

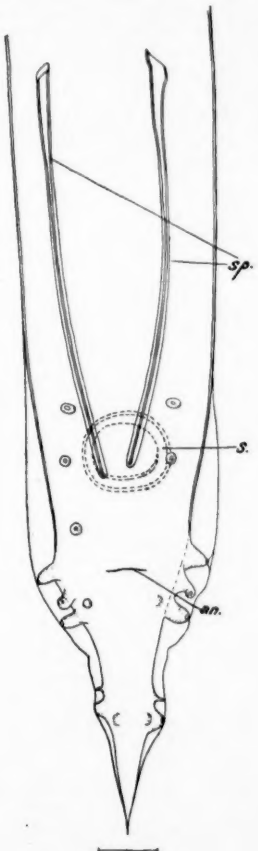

FIG. 9.—*Ascaridia lineata* (original) from the goose. *an.*, anus; *s.*, sucker; *sp.*, spicules

group consisting of 3 pairs (ventral) arranged in a linear series on each side of the sucker, the second group consisting of 4 pairs (3 lateral and 1 ventral), and the last group consisting of 3 pairs (2 lateral and 1 ventral). (figs. 10, 11, 12, 13.)

VARIATIONS IN ASCARIDIA LINEATA

HEAD.—The head varies in size corresponding to different sized specimens. The two subventral lips are practically equal in size, while the dorsal lip is somewhat larger. As has already been stated, Schneider (*13*) described two dentigerous ridges, the second one, according to this worker, being very small. Lane (*5*) refers to only one ridge which

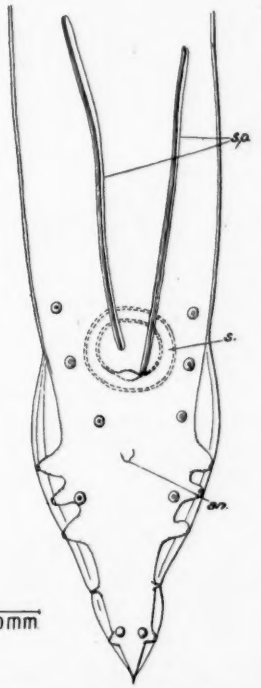

FIG. 10.—*Ascaridia lineata* (original) from the chicken. *an.*, anus; *s.*, sucker; *sp.*, spicules

he states has the appearance of a wavy line when viewed from certain aspects. The present writer observed a rather prominent dentigerous ridge, containing distinct teeth, but failed to make out a second smaller dental plate referred to by Schneider. Each lip bears two papillae, these having been also observed by Lane (*5*). No interlabia are present.

OESOPHAGUS.—In adult specimens the oesophagus is 3 mm. to 4 mm. long, club shaped, and about 0.35 mm. in

maximum width. In immature specimens the oesophagus is relatively shorter and narrower (fig. 14), various gradations in length and width, depending upon the size of different specimens having been observed.

PAPILLAE.—While the number of papillae in the male of *Ascaridia lineata* is constant, the positions of the individual papillae with respect to one another and the direction of the first ventral and second lateral papillae are rather variable (figs. 4 to 13). It has already been pointed out that certain writers describe the first ventral papilla as lying in a transverse direction (figs. 5, 6, and 7), whereas other observers, including Lane (*6*), have figured it as spherical (figs. 4 and 8). The present writer found that in most cases the first ventral papilla is transversely flattened, although in one immature specimen from the goose it was spherical in shape (fig. 9). With regard to the second lateral papilla, it was observed to be directed laterally in all specimens examined, save in one immature form from the goose, in which the papilla was directed ventrally (fig. 9).

Other variations with regard to the papillae are as follows: The last two lateral papillae were found to be very close together in certain specimens and comparatively distant from each other in other specimens. In the middle group of papillae the three lateral papillae were found to be equidistant in some specimens, whereas in other specimens the two anterior papillae of this group were close together and the most posterior papilla relatively distant from the middle papilla. The lateral papillae also show considerable variation in size, relatively large papillae occurring in mature specimens and smaller papillae in very young specimens. The ventral papillae afford the same degree of variation as regards location, shape, and size, the latter variation being correlated with age. The first ventral papilla is considerably anterior to the sucker in certain specimens, whereas in others it is on a level with or somewhat anterior to the cephalad border of the sucker. The fourth ventral papilla is fairly constant in position, somewhat posterior to the

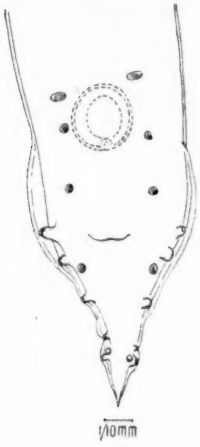

FIG. 11.—*Ascaridia lineata* (original) from the chicken

FIG. 12.—*Ascaridia lineata* (original) from the chicken

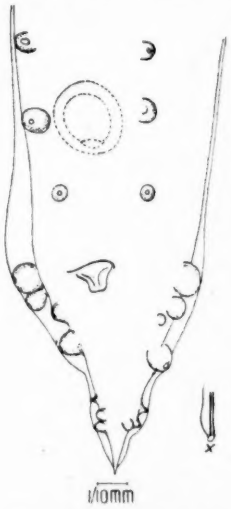

FIG. 13.—*Ascaridia lineata* (original) from the chicken. *x*., tip of spicule

second lateral papilla, but the location of the last ventral papilla is rather variable, being anterior to the last lateral papilla in certain specimens and posterior to it in other specimens. Not infrequently the arrangement of the papillae on the two sides of the bursa is asymmetrical (fig. 8). The position of the first lateral papilla with respect to the anus is also somewhat variable, being located either slightly anterior to, on a level with, or rarely somewhat posterior to the anus (figs. 4 to 13).

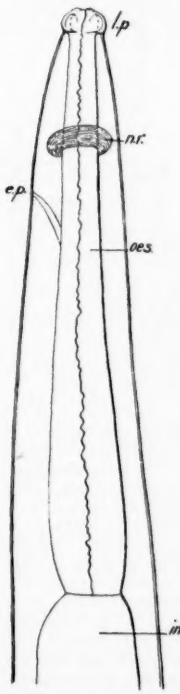

Fig. 14.—Anteria end of *Ascaridia lineata* (original). *e. p.*, excretory pore; *n. r.*, nerve ring; *oes.*, oesophagus.

SPICULES.—A considerable range of variation exists as regards the length of the spicules in *Ascaridia lineata*. According to Travassos (*16*), the spicules are 1.4 mm. long. According to Lane (*5*), they are 2 mm. long. Von Linstow (*8*) states that the spicules of *Heterakis inflexa* (misidentification of *Ascaridia lineata*) are 1.9 mm. long. Immature specimens from the chicken and goose from Tonkin, 1.8 mm. long, showed a range in spicule variation from 0.53 to 0.57 mm. in length. Somewhat larger specimens from chickens had spicules measuring from 0.7 to 0.8 mm. Spicules from not quite fully grown specimens from chickens in the Philippines varied from 0.9 to 1.3 mm. in length. Mature specimens from chickens from Tonkin showed a variation in the length of the spicules from 1.6 to 2.4 mm. Specimens from the United States showed a similar variation in the size of the spicules, the youngest immature forms measured having spicules 0.6 mm. long, whereas large mature forms had spicules somewhat in excess of 2 mm.

In view of the specific importance that is commonly attributed to the size of the spicules in nematodes, the rather wide range of size variation noted in this species is worthy of emphasis.

SUCKER.—The size of the sucker as given by Lane is 0.2 mm. in diameter, agreeing closely with that of Travassos and Boulenger (so far as can be judged from the latter's figure for which a scale is given). The maximum diameter of the sucker as observed by the present writer was 0.25 mm. and the minimum diameter in very young specimens was somewhat less than 0.14 mm

Additional variations were observed as regards the distance of the nerve ring and excretory pore from the cephalic extremity, the length of that portion of the vagina that extends cephalad, and the length of the tail in both sexes. The most conspicuous of these variations are given below: According to Lane (*5*), the vagina runs cephalad for a distance of about 1 mm. before it turns caudad. In very young forms the writer found that the vagina runs cephalad for a distance of only 475 μ (fig. 15), while in somewhat larger specimens that distance was found to be 670 μ. In mature specimens the cephalad portion of the vagina was found to be somewhat longer than that given by Lane. The tail of the male in fully grown specimens was found to be 0.7 mm., as compared with 0.5 mm. given by Lane, with a decrease in size in smaller specimens. The distances of the excretory pore and nerve ring from the cephalic extremity were found to be somewhat greater than those given by Lane in fully grown specimens, but considerably shorter in immature specimens (fig. 14).

The position of the vulva is near the equator according to Lane (*5*), which corresponds to the observations of the present writer. According to Travassos (*16*) it is in the first third of the body. The size of the eggs, which are thick shelled, the shell being smooth, is

about 80 by 50 μ according to observations of the present writer (fig. 16), which is in agreement with the size given by Travassos but is larger than that given by Lane (65×40 μ). Since practically all of Lane's measurements fall short of the present writer's measurements, it may be concluded that no such actual discrepancy as regards the size of the eggs which Lane's figures indicate really exists, the difference being due in all probability to some slight fault in the calculation of measure ments.

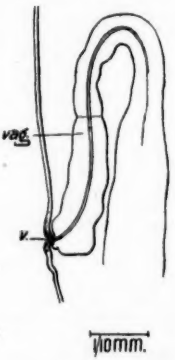

FIG. 15.—Vulva and vagina of *Ascaridia lineata* (original). v., vulva; vag. vagina

Fig. 16.—Eggs of *Ascaridia lineata* (original)

SPECIFIC DIAGNOSIS OF ASCARIDIA LINEATA SCHNEIDER, 1866

Synonyms.—*Heterakis perspicillum* Von Linstow, 1894 (misdetermination); *Ascaridia hamia* Lane, 1914; *H. braziliensis* Magalhães, 1892 (according to Travassos, 1913).

Mature specimens 70 to 120 mm. long by about 1 mm. or more wide, the females being larger than the males. Lips prominent, each lip provided with two papillae and a dentigerous ridge bearing distinct teeth. Oesophagus simple, from 3 to 4 mm. long by 0.34 mm. wide in adult specimens. The nerve ring is located approximately anterior to the first fourth of the oesophagus and the excretory pore is posterior to the nerve ring.

MALE.—Ten pairs of papillae arranged in 3 groups, as follows: An anterior group of 3 pairs of ventral papillae arranged on each side of the sucker, the middle pair of this group of papillae being alongside, the anterior pair being on the level with or anterior to, and the posterior pair being posterior to the sucker; a second group consisting of 3 pairs of lateral and 1 pair of ventral papillae, all being postanal in position with occasional variations in which the first lateral papilla may be on a level with or somewhat anterior to the anus; a third group of 2 pairs of lateral and 1 pair of ventral papillae in the region of the tip of the tail. Spicules, variable in size, minimum length 0.54 mm. in young forms and maximum length 2.4 mm. in adult forms; provided with sheaths. Spicules terminate in a rather prominent rounded enlargement (fig. 17). The sucker is circular, variable in size, measuring from 0.2 to 0.25 mm. in adult specimens; considerably smaller in immature forms. The length of the tail, which ends in a slender tip in adult forms, is from 0.5 to 0.7 mm.

FIG. 17.—Tip of spicule of *Ascaridia lineata* viewed from different aspects (original)

FEMALE.—The vulva lies approximately at the middle of the body. Eggs thick-shelled, elliptical in shape, 80 μ long by 50 μ wide. Anus from 1.1 to 1.3 mm. from tip to tail in adult forms and shorter in immature forms. Tail ends in a slender tip (fig. 18).

HOSTS.—*Gallus domesticus*, *Anas boschas domesticus*, and *Anser domesticus*.

LOCALITIES.—Europe, North and South America, Asia, and Africa.

THE GENUS ASCARIDIA DUJARDIN, 1845

Railliet and Henry (*11*) define the genus Ascaridia as follows: Mouth with three lips; esophagus without a bulb, often with lateral membranes. Caudal alae of male feebly developed. Spicules equal or subequal, without an accessory piece. Preanal sucker rounded, with chitinous ring; papillae relatively large. Vulva toward the middle papillae of the body; uteri opposed; eggs thick-shelled.

In a paper on suckered roundworms, Lane (*5*) amends the diagnosis of the genus Ascaridia as given by Railliet and Henry, by adding the following generic characters: 10 pairs of caudal papillae in the male, and similar spicules. In a later paper Lane (*6*) discusses the generic diagnosis of Ascaridia in greater detail, insisting on the view that species having more than 10 pairs of papillae that are now assigned to the genus Ascaridia should be placed in another genus, but he makes no further reference to similarity in size of spicules. According to Travassos (*16*), the male of *Ascaridia columbae* has 14 pairs of papillae; that of *A. truncata*, the type species of the genus, 15 pairs, and that of *A. magalhaesi* 12 pairs. In addition

to the forms just mentioned, there are several species of Ascaridia that have more than 10 pairs of papillae in the male. So far as concerns *A. truncata* of Travassos, Lane considers it congeneric with *Gireterakis girardi*, a new genus and new species having a bulbed oesophagus, described by himself, and he therefore concludes that *A. truncata* of Travassos is not

FIG. 18.—Tail of female of *Ascaridia lineata* (original)

identical with *Fusaria truncata* of Zeder, the type species of the genus Ascaridia. Lane has assumed that the species described by Travassos as *A. truncata* possesses a bulbous oesophagus and therefore does not belong to the genus Ascaridia. In the writer's opinion this assumption is unwarranted. In the absence of definite information to the contrary it seems fairer to assume that the species designated by Travassos as *A. truncata* has a simple oesophagus characteristic of the genus Ascaridia, a fact which is clearly implied in the generic diagnosis of Ascaridia as given by Travassos. Lane's additional assumption that *A. truncata* of Travassos included more than one form must be left open to question in the absence of definite information on this point. The point to be considered in this connection is that *A. truncata* of Travassos is a parasite of birds, whereas *Gireterakis girardi* is a mammalian parasite, the difference in host relationship of the two forms favoring the probability of their being different genera.

One point on which Lane and Travassos agree, however, is the importance of the structure of the oesophagus in the classification of suckered roundworms. Lane (*6*), referring to the members of the genus Ascaridia, states that they will probably be subdivided in the future into several genera and will come to occupy the status of a subfamily at least, and that the genera Heterakis, Ganguleterakis, Gireterakis, and related forms having a bulbed oesophagus will constitute another subfamily. Future investigation may perhaps justify Lane's position, but there appears to be no need at the present time to limit the definition of the genus Ascaridia beyond what is given by Railliet and Henry (*11*).

SYSTEMATIC POSITION OF ASCARIDIA LINEATA

In common with other species of the genus, *Ascaridia lineata* is generally referred to the family Heterakidae, which is included in the superfamily Ascaroidea. According to Travassos (*17*), whose conception of the nematode superfamilies is to some extent at variance with that of Railliet and others, the genus Ascaridia belongs to the family Ascaridae, and not to the family Heterakidae, which he limits to forms having a bulbous oesophagus. Travassos furthermore assigns the family Heterakidae to the superfamily Oxyuroidea, thus placing the genus Ascaridia in a different superfamily, namely, Ascaroidea. This conception of the affinities of the genus Ascaridia differs radically from that of Railliet and Henry (*11*), who place Ascaridia with other suckered roundworms in the family Heterakidae. The genus Ascaridia has undoubted affinities with certain Ascaridae so far as concerns the structure of the oesophagus and the presence of dentigerous ridges on the lips, but so far as concerns the presence of a preanal sucker and a bursalike tail in the male, it is closely related to the Heterakidae.

The zoological position of the genus Ascaridia is a question that can not be finally settled until careful morphological comparisons are made not only of the adult forms, but also of the larvae at various stages of development, with those of corresponding stages of genera of Ascaridae on the one hand and with genera of Heterakidae on the other.

SUMMARY AND CONCLUSIONS

The principal facts presented in the foregoing pages may be summarized as follows:

Ascaridia lineata is the common intestinal roundworm of chickens in the United States, the occurrence of *A. perspicillum* in this country not having as yet been established on the basis of morphological comparisons of Ascaridia occurring in American chickens with the different forms that have been described as *A. perspicillum*.

So far as can be judged from the various illustrations of *Ascaridia perspicillum*, this species is either highly variable as regards the arrangement and location of the papillae in the tail of the male, or else several different species have been confused under one name.

Ascaridia lineata exhibits considerable individual variations, these being correlated with size and therefore with age of the different specimens. Of special interest in this connection is the variation in the length of the spicules, organs to which considerable specific importance is usually assigned by helminthologists. Of perhaps equal importance is the variation in the size of the sucker, which has a chitinized rim.

Ascaridia lineata is recorded for the first time as a parasite of the goose, on the basis of specimens from Indo-China.

In view of the apparent absence of *Ascaridia perspicillum* from American chickens, various facts published in the United States concerning the life history, pathology, and physiology of *A. perspicillum* as well as facts pertaining to medicinal treatment in all probability refer to *Ascaridia lineata*.

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SOME LABORATORY METHODS FOR PARASITOLOGICAL INVESTIGATIONS [1]

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INTRODUCTION

The post-mortem examination of the viscera of animals for parasites constitutes a large part of the work of a laboratory of parasitology, and the efficiency of the work depends largely on the effectiveness of the methods used in such examinations. Owing to the general prevalence of parasites in the digestive tract, the examination of this tract is of special importance.

The method of examining the digestive tract which is most widely employed in laboratories is substantially as follows: The esophagus is removed, slit with the indispensable enterotome, and examined by reflected light for evidence of parasites superficially visible and by transmitted light for parasites embedded in the tissue and not superficially visible. The stomach is opened into a jar of water or physiologic saline solution, the contents washed out, the stomach itself examined internally, externally, and if possible by transmitted light for parasites present, and the stomach contents repeatedly sedimented and washed until the supernatant water or saline solution is clear, the sedimented contents then being examined a bit at a time after being poured into wide, shallow glass dishes. The small intestine or its component portions, the cecum, and the large intestine or its component portions are examined in the same manner as the stomach.

This method has long been in use and is, as a rule, a fairly satisfactory procedure. It is best suited for examining the digestive tract of such animals as dogs. In the case of a larger animal, such as a horse, cow, or sheep, the contents of the stomach and large intestine are so bulky that this method of examining is unsatisfactory, and as a rule the examination is confined to the region of the mucosa and the contents near the mucosa, the interior of the mass of ingesta or fecal material receiving little or no attention in many cases. This was the method employed by Looss [2] in examining horses for parasites. In some cases the contents of the large intestine (cecum and colon) of the horse are examined by pressing the material into balls and picking these apart by hand. This was the method employed by Hall, Wilson, and Wigdor [3] and they used the same method for examining the manure of horses for worms passed after anthelmintic treatment.

THE USE OF SCREENS

It has occurred to the writers that the use of the graduated set of screens which they find indispensable in examining feces for parasite eggs and for worms passed after anthelmintic treatment in the case of dogs and similar small animals, might be of value in post-mortem examination as well. Various other writers, such as Stiles, Cobb, Telemann, Bass, and Garrison, had advocated the use of a screen or sieve of metal, gauze, or bolting cloth in the examination of feces for parasite eggs; but the advantage of a set of metal screens of graduated sizes, set in a rack in the order of size with the largest-mesh screen at the top and the smallest-mesh screen at the bottom, appears to have been emphasized first by Hall.[4] This set of screens was also used in examining feces for worms passed after anthelmintic treatment in critical testing of anthelmintics by Hall and Foster.[5] The usefulness of assorted screens for the separation of mixtures of objects of various sizes is generally recognized in industrial procedures. Feces and gastro-intestinal contents are mixtures of this sort.

[1] Received for publication June 30, 1924; issued June, 1925.

[2] LOOSS, A. THE SCLEROSTOMIDAE OF HORSES AND DONKEYS IN EGYPT. Rec. Egyptian Govt. School Med. 1901: 25–138, illus. 1901.

[3] HALL, M. C., WILSON, R. H., and WIGDOR, M. THE ANTHELMINTIC TREATMENT OF EQUINE INTESTINAL STRONGYLIDOSIS. Jour. Amer. Vet. Med. Assoc. (n. s. 7) 54: 47–55. 1918.

[4] HALL, M. C. A COMPARATIVE STUDY OF METHODS OF EXAMINING FECES FOR EVIDENCES OF PARASITISM. U. S. Dept. Agr., Bur. Anim. Indus. Bul. 135, 36 p., illus. 1911.

[5] HALL, M. C., and FOSTER, W. D. EFFICACY OF SOME ANTHELMINTICS. Jour. Agr. Research 12: 397, 447, illus. 1918.

In their experiments, the writers have substituted the use of screens for the sedimentation and washing method in examining the digestive tract in all cases where such a substitution saved time. The screens used were the same ones used by Hall and by Hall and Foster. These screens were made by taking round tin pans with a bottom diameter of about 6.5 inches and a slightly greater top diameter, with sides 2 inches high, and with a projecting flange rim at the top, cutting out most of the bottom of the pan, but leaving a small flange projecting inward, and soldering brass screening of assorted sizes to the bottom flanges of the various pans. Some of the pans were enameled and some shellacked to prevent rusting. The enamel and shellac have never been renewed since the first coat, and these screens—very cheap affairs to begin with—are still serviceable after about 14 years of constant use. The expense of screens is therefore a very small matter, and even poorly equipped laboratories can easily afford them.

A much better set of screens for the purpose has been described by Hall.[6] These screens (fig. 1) are of copper and are about 7⅞ inches (20 cm.) square in inside dimensions. They are made of two copper strips, swaged together at two diagonal corners, the top half-inch of the metal being bent over and doubled back against the side on two opposite sides to form a reinforced flange ¼-inch wide which carries the screen in a rack. The copper sides are 2 inches high. On the bottom of the screens the metal is bent in to form a flange ⅜ inch wide for the attachment of the brass screening, which is soldered to this flange. The screens described had mesh apertures of 6, 8, 10, 14, 16, 20, 60, 100, and 120 to the inch, the latter being about the finest screen that will permit of the passage of the eggs of practically any worm parasite. Each sieve has a number stamped in the front side to show its number of mesh apertures to the inch. A solid-bottomed copper pan, of the same shape and dimensions as the screens, completes the set. A rack with grooves in its solid board sides or with transverse pieces on the sides and back of a skeleton construction of upright pieces is provided, and the screens are supported by the grooves or transverse pieces when they are set up in the rack. The number of screens used in any operation will vary with the nature of the material examined and the judgment of the operator.

The material which the writers have examined post mortem by means of screens consisted mostly of the contents of digestive tracts of dogs killed at the end of experiments in critical testing of anthelmintics, and of digestive tracts of wolves, coyotes, lynxes, and one bear sent in by the field service of the Biological Survey of the Department of Agriculture in response to a request by the Zoological Division for this material. The viscera of the dogs were fresh. The viscera of the wild carnivores were sent from the field wrapped in borax or in cloth saturated in formaldehyde solution, some of them coming from as far as California, and were often a week or ten days old when received.

THE SCREENING METHOD

The method of screening the contents of practically all portions of the digestive tract, including the stomach, small intestine, cecum, and large intestine, was first tested, each of these portions being opened separately into a jar of water and each screened separately. For this purpose the three screens having 6, 12, and 24 mesh apertures to the inch were generally used. The finest of these screens shows some little variation in its mesh apertures and may have in places 21 or 22 mesh apertures to the inch. It is not so fine as could be desired for the final screen, and the 60-mesh screen was sometimes used as a final screen. One with a mesh aperture of perhaps 40 to the inch should probably be added to the set. The number of screens and the mesh sizes to use are matters of individual judgment. The screens should be used in a rack for various reasons, one reason being that this results in cutting down the water pressure on the last screen and diminishing the likelihood of washing worms through that screen by high-water pressure.

The advantages of this method over the sedimentation and washing method are very evident. As soon as the contents of a jar are poured on the screen, a hose which is attached to a water tap having a foot-pedal control for the flow is used to wash the material on the top screen until it is clean and comminuted as much as possible. The pressure of the water and the amount of washing are matters of individual judgment. The water runs

[6] HALL, M. C. APPARATUS FOR USE IN EXAMINING FECES FOR EVIDENCES OF PARASITISM. Jour. Lab. and Clin. Med. 2: 347-353, illus. 1917.

through to the lower screens and washes the contents which pass through from the top screen. Most of the unpleasant odor of the ingesta and fecal material (and the odor of viscera packed in borax for 10 days is decidedly unpleasant) is associated with the fine material which passes through the last screen, and this is promptly washed down the sink in which the rack is set. The less unpleasant material, with whatever parasites may be present, remains on the screens and is transferred to shallow glass dishes either by washing or by immersion in water in the dishes and tipping to remove all or part of the contents at a time. In either case the screens are placed in water in the dishes and examined for parasites that may be held on them or in their meshes.

In most cases this method of examination shows the following advantages over the sedimentation and washing method: There is a great saving of time, as washing through the screens is a much quicker process than sedimenting and washing repeatedly to remove the supernatant discolored fluid and flocculent material. The parasites are washed out of the ingesta, making their recognition and collection easier and more certain. The malodorous material is removed much more promptly and the entire process of examination is much pleasanter.

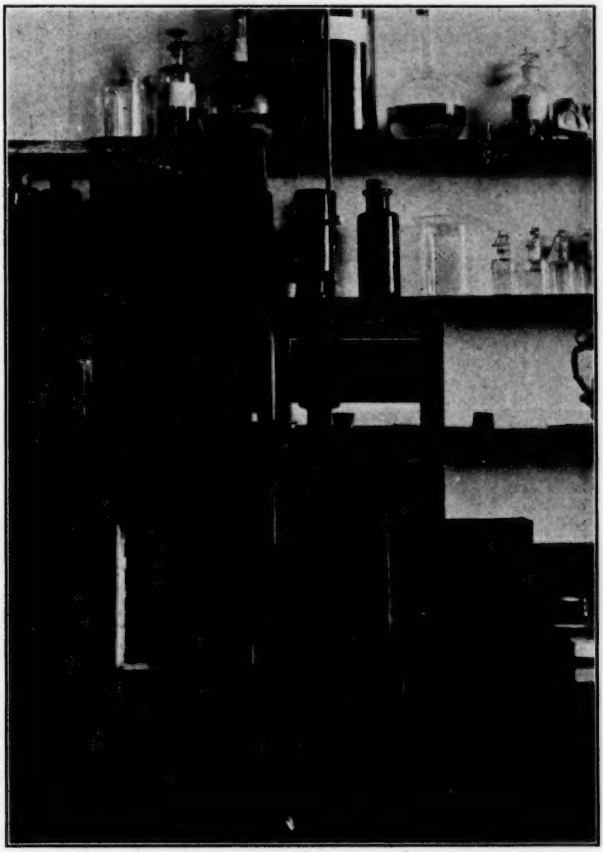

FIG. 1.—A set of copper screens, some on skeleton rack with transverse pieces at left, some in solid board rack with grooves at right, one on edge at bottom of left-hand rack, and one, seen partly from above, on the table in the center; solid copper pan on edge at right. (From Hall, 1917.)

The disadvantages of this method of screening are mostly theoretical and generally follow errors of judgment. In the first place, it was found that in practice time could not always be saved by substituting the screening method for the sedimentation method. These cases were usually those in which washing itself was unnecessary. Such cases include the examination of the practically empty stomach of a fasted dog or the almost empty cecum of individual carnivores of any sort. In these cases the organs in question could be slit open into a jar, the material allowed to settle for a few minutes, the supernatant fluid decanted, and the small sediment examined immediately, or after one washing, in a glass dish. This is a quicker procedure than screening and examining the screens, and there is little in the way of ingesta or fecal material to conceal parasites or afford unpleasant odors.

Another objection is on the score of possible injury to parasites by screening and washing. For the practical purposes of routine examination for and collection of parasites, this objection is mostly theoretical, although in special cases it would be sound. In general, worm parasites are fairly resistant structures as met with in the field of human and veterinary medicine. Such worms as the ascarids are fairly tough structures, and *Ascaris lumbricoides* has been kept alive in Kronecker's solution for 26 days, which shows that it is not readily damaged by being removed from its host and placed in an alien environment. It is true that there are some very fragile worms that are very susceptible to mechanical injury and the destructive action of osmosis in such fluids as tap water, but worm parasites of the digestive tract are rarely of this sort. It is also true that the easily lost hooks of some tapeworms may be lost by screening.

Where worms are being collected for very careful studies of their morphology a more refined technic is desirable; but for practical routine purposes the writers find the screening method superior to the sedimentation and washing process, provided one uses good judgment, and believe that the contents of the small and large intestines may be screened to advantage in almost all cases and that screening of the contents of the stomach and cecum should be carried out when of sufficient quantity to warrant it or omitted if of such small quantity that little or no washing is necessary. The screening method would be of value for the examination of swine viscera and to some extent for the examination of the viscera of such animals as sheep, cattle, and horses.

In connection with the subject of laboratory technic it is also noted that it is advisable to slit the larger air passages of the lungs and then wash and squeeze the lung in a dish of water or saline solution in order to detect worms which may be overlooked in slitting and examining without this washing. The urinary bladder, gall bladder, and similar structures also should be slit in a dish of water or saline solution and examined in the same way and for the same reason.

CONCLUSIONS

A set of metal screens of assorted mesh apertures with a suitable rack to hold them is a very valuable and almost indispensable part of the equipment of a parasitological laboratory. The screens are of service in examining feces for parasite eggs and for worms passed after anthelmintic treatment and in examining the contents of the digestive tract post-mortem. If used with judgment in post-mortem examinations they save time, make the detection and collection of parasites easier and more certain, and make the work less unpleasant by removing the malodorous portions of ingesta and fecal material more rapidly than the sedimentation and washing method does. There appears to be little damage done to parasites, as a rule, by the use of screens and washing. The lungs, urinary bladder, gall bladder, etc., should be slit open in a dish of water or saline solution and examined in this way for parasites present.

SOME LEPIDOPTEROUS LARVAE RESEMBLING THE EUROPEAN CORN BORER [1]

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INTRODUCTION

The European corn borer (*Pyrausta nubilalis* Hübner) is unquestionably the most important potential insect enemy of the corn plant in the United States and Canada. Inasmuch as there are other lepidopterous larvae attacking corn which may be readily confused with the European corn borer, it seems desirable to give an account of these larvae, to point out the structural characters wherein they differ from one another, and briefly to discuss their habits and seasonal histories in order further to facilitate the identification of the European corn borer in the field, as has been done by Heinrich (*13*)[3] for the pink bollworm and lepidopterous larvae likely to be confused with it.

The larvae of two native species, *Pyrausta ainsliei* Heinrich and *P. penitalis* Grote, which also inhabit corn at certain seasons of the year, so closely resemble the larvae of *Pyrausta nubilalis* in color, size, and structure that their identification without final resort to the microscope will always remain uncertain. Immature larval stages of these three forms are especially difficult to separate. Other plants than corn attacked by the European corn borer are hosts of lepidopterous borers and surface feeders, some of which, although entirely unrelated to one another, resemble more or less closely the larvae of *P. nubilalis*. In order to draw a line, however, as to the forms to be included in this category, special consideration is given only to those larvae inhabiting the preferred food plants of the European corn borer. Field observations in connection with the species discussed were conducted in the Massachusetts area infested by the corn borer, unless otherwise indicated.

It was necessary in this work to make distinctions between food plants and shelter plants, as Ainslie and Cartwright (*1, p. 837*) also found necessary in their work on the biology of *Pyrausta ainsliei* in Tennessee. Generally, the naming of a particular plant as a host plant implies that the insect feeds upon it and derives its livelihood therefrom. This is not strictly true, however, for some lepidopterous larvae boring in weeds and other plants migrate at certain seasons of the year, particularly in the autumn, to other apparently more suitable plants in which they find desirable quarters for the winter (*2*). Usually the larvae possessing this migratory habit—those observed—are full grown in the fall and consequently require no further food in the spring for the continuance of their development. They have lived at the expense of small marrowed or pithy stems. When completely tunneled out, these stems are obviously frail and when subjected to the rigors of winter in the north are readily broken over, frequently exposing the burrows of the larvae within. Thus the larvae are feebly protected unless they migrate to more favorable situations or mine into the underground stems of the plants they infest, as do Gnorimoschema and Pterophorus in *Solidago sempervirens* L. Plants which afford only wintering or pupation quarters for an insect should be termed shelter plants. The term "host plant" is relative.

Eleven species are considered in the present paper. Descriptive matter in the text has been reduced to a minimum; the important differentiating structural characters, however, are pointed out and further emphasized by figures.

[1] Received for publication Apr. 22, 1924; issued June, 1925. This study was projected by D. J. Caffrey, in charge of the European corn borer investigations, as an aid for field men. The writer materially benefited from his enthusiasm, suggestive criticisms, and general supervision of the work, and desires hereby to express his appreciation and thanks. It should also be stated that Carl Heinrich, of the Bureau of Entomology, read the manuscript, pointed out omissions, and suggested several important changes both in the text and in the figures.

[2] Resigned Jan. 12, 1925.

[3] Reference is made by number (italic) to "Literature cited," p. 792.

FAMILY PYRALIDAE

SUBFAMILY PYRAUSTINAE

PYRAUSTA NUBILALIS HÜBNER

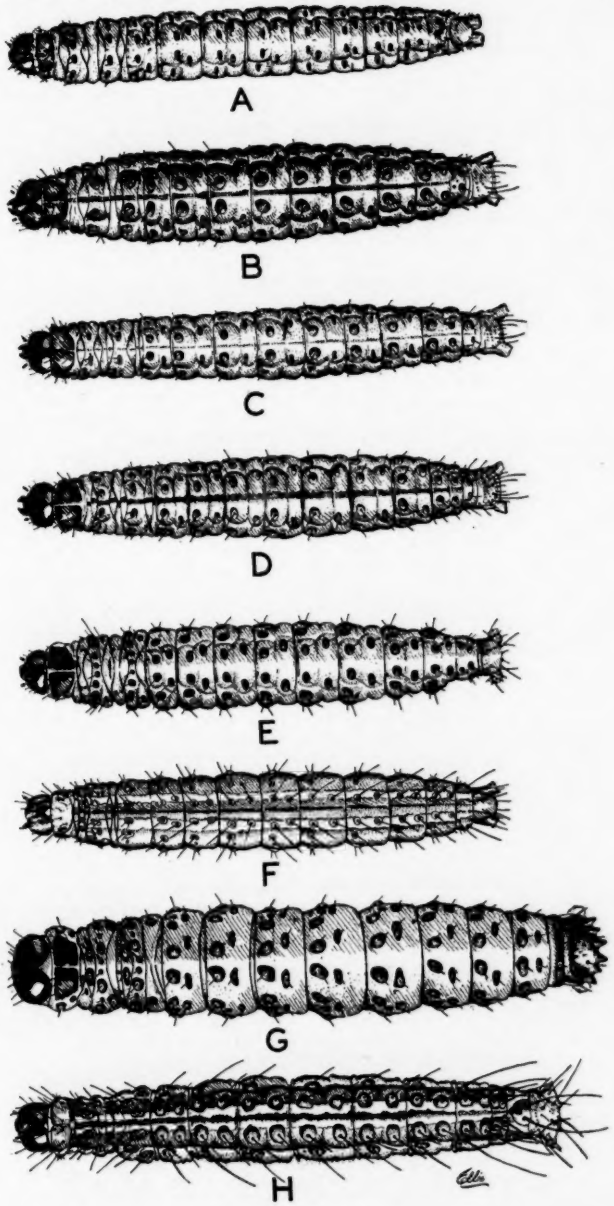
Pyralis nubilalis Hübn., 1796, Eur. Schmett., Sechste Horde, 25, 14, Pyr., pl. 14, fig. 94.
Pyralis silacealis Hübn., 1796, Eur. Schmett., Sechste Horde, 25, 15, Pyr., pl. 18, fig. 116.
Pyralis glabralis Haw., 1811, Lepidop. Brit., p. 380.
Botys lupulinalis Clerck, Guenée, 1854, Delt. et Pyr. (Bdv. et Guen., Hist. Nat. Ins. Lépidop.) 8: 331.
Botys zealis Guen., 1854, Delt. et Pyr. (Bdv. et Guen., Hist. Nat. Ins. Lépidop.) 8: 332.
Botys lupulina Heinemann (nec Clerck), 1865, Die Schmett. Deutsch. und der Schweiz, 1, 2, 70.
Hapalia kasmirica Moore, 1888, New Ind. Lepidop. Ins., p. 222, pl. 7.
Hapalia lupulina Butler (nec Clerck), 1889, Illus. Typ. Spec. Lepidop. Het. Coll. Brit. Mus. 7: 19.
Pyrausta nubilalis Hübn., 1901, Staud. and Rebel, Cat. Lepidop. Aufl. 3, 2: 65, No. 1218.

For complete information on the status, habits, life history, etc., see paper by Vinal and Caffrey (*21*).

The European corn borer (*Pyrausta nubilalis* Hübn.) was described by Hübner in 1796 as *Pyralis nubilalis*. The description consisted of a careful drawing of the male and a descriptive note added to the text of "Sechste Horde." Hübner also described the female as *silacealis* in the same manner with a figure and a note, apparently not recognizing, owing to the complete difference in coloration of the two sexes, that this species was the female of his *nubilalis*. It seems that Clerck (*3, Sect. I, pl. 9, fig. 4*) in 1759 attempted to describe a species under the name *Phalaena lupulina*, but executed so poor a figure that the majority of workers have disregarded it. Guenée, although admitting that Clerck's figure is poor, believed that *lupulina* should take precedence over Hübner's *nubilalis*, since he was convinced that they were identical. He therefore assigned the name *Botys lupulinalis* to the species, giving Clerck credit for the authorship, and several succeeding writers have used the name *lupulina* of Clerck for Hübner's species. A study of Clerck's figure by later workers, however, has convinced them that Clerck's *lupulina* is not identical with Hübner's *nubilalis*. Since then the species has been described under a variety of names, but all recent catalogues on Lepidoptera maintain the name *nubilalis* Hübner. On account of priority, the generic name Botys erected by Latreille in 1802 has been supplanted by Schrank's Pyrausta of 1801.

The full-grown larva of the European corn borer (description, *11, p. 174*) (pl. 1, D) averages 0.81 of an inch in length, or 19.95 mm. (*20, p. 27*). The integument on the dorsal side of the larva is heavily granulated, the granulations extending to the pleura of the body segments. Laterad and ventrad the integument is a dirty white. The skin granules carry the pigmentation which varies from a pink, slate gray, or "smoky-fuscous" (*11*) to a light brown. Since each color may predominate over the other, various color combinations are present in living larvae which are obviously difficult to describe. The skin granules are most dense on the dorso-median plane and take the form of a distinct stripe which is more or less interrupted where the integument folds in on the dorsal side of the larva to delimit the body segments; notwithstanding this interruption, the stripe is plainly visible to the unaided eye as a dark, pigmented, longitudinal band. On the larva of *Pyrausta ainsliei*, a close relative of the larva of the European corn borer and almost identical with it structurally, this stripe or band is very insignificant (pl. 1, C), narrow, and difficult to establish as present. This difference has been found to be a safe field character for the separation of full-grown living larvae. This character can not be depended upon for use in separating material preserved in alcohol, as it is a well-known fact that even with the utmost care in preservation pigmented areas fade.

The abdominal segments bear on the integument of the dorsum or in its creases and folds small rounded clear areas, some of which appear fused with each other, forming thereby somewhat irregular moniliform clear spaces. Miss Mosher endeavored to establish the constancy of these areas on the abdominal segments (*18, p. 265*) and used them in separating *nubilalis* from *ainsliei*. Heinrich has pointed out (*11, p. 176*) that this character is elusive and unreliable. It is possible to find in a small series of selected larvae some constancy as to the number and placement of these clear areas, but in a large series of larvae the character is at once seen to be inadequate and unreliable. As to the morphology of these areas Heinrich believes by analogy that they afford attachment for certain muscles and homologizes them with similar weakly chitinized areas in certain Phycitinae—notably Dioryctria and Pinipestis by way of example (*11, p. 174, footnote*). Microscopic sections through these areas



DORSAL VIEW OF LARVAE

A.—Bidens borer, *Epiblema scudderiana*
B.—Nelumbo borer, *Pyrausta penitalis*
C.—Polygonum borer, *P. ainsliei*
D.—European corn borer, *P. nubilalis*
E.—Parsnip webworm, *Depressaria heracliana*
F.—Greenhouse leaf-tyer, *Phlyctaenia rubigalis*
G.—Spindleworm, *Achatodes zeae*
H.—Celery stalkworm, *Nomophila noctuella*

fail to reveal that they afford attachment for body muscles, cutaneous or others. It is true that they are feebly chitinized, thinner in fact than other portions of the integument, but this is apparently due in large measure to the absence of the characteristic skin granules present elsewhere on the dorsum.

Heinrich uses the anterior epicranial setal group (*11*) and puncture to separate *nubilalis* from *ainsliei*. This unquestionably is a good character, and is, as a matter of fact, the only reliable character that can be used to separate the two species in all larval stages (see *P. ainsliei* below) (pl. 2, I and J).

PYRAUSTA AINSLIEI HEINRICH

Pyrausta ainsliei Heinr. 1919, Jour. Agr. Research 18:175, pls. 7–10.
Pyrausta penitalis auct. (nec Grote).

After a careful comparison of the genitalia of the specimens of *Pyrausta penitalis* Grote in the National Museum and after a further examination of Grote's types of the same species in the American Museum of Natural History in New York, Heinrich was convinced that two species were involved and confused with each other under the specific name *penitalis*. Accordingly, he separated this species and described it as *ainsliei* from specimens furnished him by George G. Ainslie of the Bureau of Entomology, Knoxville, Tenn.

In 1920 Flint and Malloch treated a lepidopterous larva occurring in smartweed as Lederer's *obumbratalis* (*8, p. 303–304*). Heinrich (*12, p. 57*) established the identity of this species as *ainsliei*, admitting the possible synonymy but calling attention to the impossibility of fixing the actual identity of *obumbratalis* at the present time. To avoid confusion and possibly misapplication of a name, it is advisable at present to use *ainsliei* rather than *obumbratalis* as the designation for our smartweed borer.

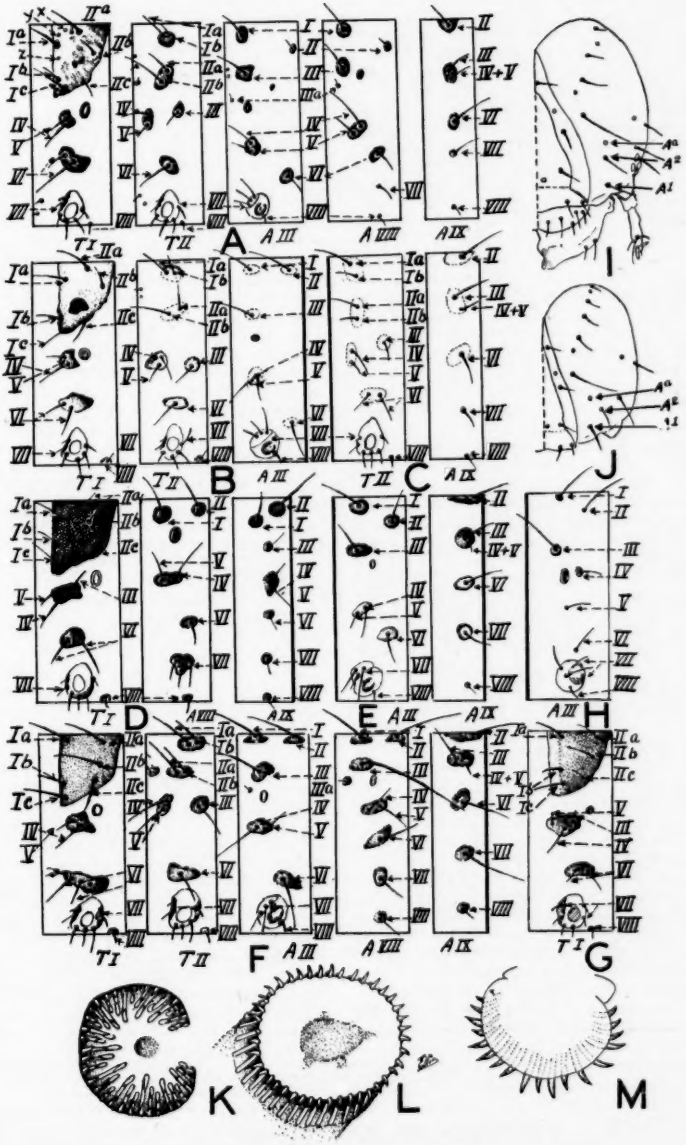
The larvae of *Pyrausta ainsliei* have been found in all stages of development in eastern Massachusetts in the following plants: *Polygonum pennsylvanicum* L. var. *laevigatum* Fernald, *P. lapathifolium* L., *P. persicaria* L. (smartweeds); *Xanthium* sp. (cocklebur); *Ambrosia artemisiaefolia* L. (ragweed); *Eupatorium* sp.? (Joe-pye weed); *Apocynum androsaemifolium* L. (spreading dogbane); *Typha latifolia* L. (cat-tail); *Chenopodium album* L. (lamb's-quarters). Adults have been bred through from second instar larvae from all these plants with the exception of Apocynum and Chenopodium. In these two cases very young larvae were taken from these plants in the field but failed to live in confinement. By subsequent visits to plants infested in the field, however, the writer was convinced that the species was developing therein. It should be stated in this connection that instances of larvae developing in plants other than *Polygonum pennsylvanicum* L., and *P. lapathifolium* L., were infrequent; so that it became apparent that the species greatly prefers the smartweed group of plants in which to breed. In the late autumn larvae have been taken from the following shelter plants: *Rubus* sp.?; *Sambucus canadensis* L. *Zea mays* (corn), *Solidago canadensis* L., *Echinochloa crusgalli* (L.) Beau. (barnyard grass), *Bidens frondosa* L. (beggar-ticks); *Typha latifolia* L., *Apocynum androsaemifolium* L. In November Vickery sent a lot of cotton plants collected at Wilmington, N. C., February 11, 1921, to the Arlington, Mass., laboratory, from which many larvae of *Pyrausta ainsliei* were cut. Cotton is probably a shelter plant.

Ainslie and Cartwright published some results obtained on the biology of *ainsliei* in which they list (*1, p. 838*) the following as reported natural food plants: *Polygonum pennsylvanicum* (var. not given), *P. lapathifolium*, *P. persicaria*, *P. hydropiperoides*. They also reared the larvae in confinement

EXPLANATORY LEGEND FOR PLATE 2

LARVAL DETAILS

A.—Setal map of *Pyrausta nubilalis*, prothoracic, mesothoracic, and third, eighth, and ninth abdominal segments of larva. (After Heinrich)
B.—Setal map of *Phlyctaenia rubigalis*, prothoracic, mesothoracic, and third abdominal segments
C.—Setal map of *Diatraea zeacolella*, mesothoracic and ninth abdominal segments. (*14, pl. 4*)
D.—Setal map of *Depressaria heracliana*, prothoracic and eighth and ninth abdominal segments
E.—Setal map of *Loxostege similalis*, third and ninth abdominal segments
F.—Setal map of *Nomophila noctuella*, prothoracic, mesothoracic, and third, eighth, and ninth abdominal segments
G.—*Epiblema scudderiana:* Setal map of prothorax
H.—*Heliothis obsoleta:* Setal map of third abdominal segment
I.—*Pyrausta nubilalis:* Cephalic view, left half of head
J.—*P. ainsliei:* Cephalic view, left half of head capsule
K.—*P. nubilalis:* Crochets on plantum of pseudopodium
L.—*Epiblema scudderiana:* Crochets on plantum of pseudopodium
M.—*Heliothis obsoleta:* Crochets on plantum of pseudopodium. (After Heinrich)



(For explanatory legend see p. 780)

on the leaves of *Rumex crispus* (curled dock) and *Fagopyrum fagopyrum* (buckwheat).[4] These workers have found the larvae in the following plants, which they assume to be purely shelter plants: *Zea mays* (corn), *Ambrosia trifida* and *A. artemisiaefolia* (ragweeds) *Xanthium communis*, cocklebur) *Solidago* spp. (goldenrod), *Aster* spp. (aster), *Phleum pratense* (timothy), *Typha latifolia* (cat-tail), *Bidens bipinnata* and *B. frondosa* (beggarticks), *Brassica arvensis* (wild mustard) (recorded by Felt), *Eupatorium* sp.? (Joe-pye weed) (recorded by Chittenden). Since both *nubilalis* and *ainsliei* possess this migratory habit, the former perhaps to a less degree, it will not be surprising if the larvae are taken in many plants and in other situations affording suitable quarters in which to pass the winter. Flint and Malloch (*8, p. 293*) published a substantial list of plants in which the larvae of *ainsliei* have been taken in the fall.

It is amazing that a species so abundant and so widely distributed as *ainsliei* should have remained undiscovered until so recent a time. It occurs abundantly wherever it has been reported as present, from Quebec, south through New England, New York, New Jersey, Pennsylvania, Maryland, Virginia, the Carolinas, and Tennessee, to Florida, west through Mississippi to Louisiana, and north through Kansas and Iowa to Michigan. It doubtless has a range even greater than we know of at present.

In Massachusetts the insect has a single brood (very often a partial second), in New York apparently one generation (Bartley and Hofer[5]); in Northern Ohio apparently two generations (Poos[5]); in Iowa two generations (*20*); in Tennessee two generations (*1*); and in Mississippi three generations (Allen[5]). In New England the moths appeared in 1921 the first week in June, emergence continuing through July 10, on which date the last pupa was observed in the field. Larvae were full grown by September 1, although many immature were also present in the field. On September 12, 1921, the writer first observed the larvae in corn for the season and from this date until October 5 their numbers appeared to increase constantly in corn plantations and in other places of shelter. In confinement, pupae remained as such for an average period of 15.3 days.[6] Egg masses hatched on the average in 6.5 days.

Small holes in the stalks of Polygonum and other plants with frass extruding and suspended somewhat beneath the openings indicate where the borers are at work in the plant. The tissue about the opening is usually slightly sunken and discolored. Since a large number of borers can be found at work in a single plant it is common to find the Polygonums on dumps and at wayside places in a state of utter collapse. On opening such infested plants one finds in place of the customary pith and fleshy medulla, a mass of castings, larvae, and larval exuviae. Prior to pupation, the larvae cut exits in the stalk for the convenience of the moths, covering these openings with tympana of silk. The larvae rarely mine through the septa of the nodes of Polygonum but confine their feeding almost exclusively to the internodes. The larvae are much less active than the larvae of *Pyrausta nubilalis;* in fact, they are comparatively sluggish. Corn borers, on the slightest disturbance or provocation, move out of their quarters; *ainsliei* larvae remain to be prodded out or summarily removed by hand.

Observations made by the writer in New England on the developing larvae do not completely coincide with those made by Ainslie and Cartwright in Tennessee (*1, p. 840*). The young larvae, for the most part, do not at once enter the stems of Polygonum, but invariably on emergence from the eggs they freely pit the midrib and feed on the epidermis of the under surface of the leaves which hold the egg masses. During the time the larvae are thus engaged the chitin of the mandibles fully hardens and the head capsule assumes its normal pigmentation. It is true that immediately following their escape from the eggs the young larvae remain assembled in gregarious fashion, but in the course of a day they disperse,

[4] In this connection Ainslie and Cartwright also state (*1, p. 838*): "Leaves of all common weeds and plants were offered to the larvae, but in every case except the two mentioned above they were either refused or only slightly gnawed." This general statement implies that all common weeds and plants from various sections of the country were offered to the larvae. These investigators probably mean that the most common weeds and plants in the vicinity of Knoxville, Tenn., were utilized in experimentation.

[5] Unpublished.

[6] Wm. B. Turner, of the Sacramento Entomological Laboratory of Cereal and Forage Insect Investigations, was connected with the European Corn Borer Laboratory and directly associated with the work in 1920 and 1921. He secured the pupation records, devised cages, and contributed other important data to our knowledge of *P. ainsliei*. Mr. Turner died June 12, 1924.

entering the stems of the plant near where the eggs were deposited. As a result of larval feeding these small stems wilt. The larvae, therefore, leave these, migrating elsewhere to another section of the plant, and they may do so several times in the course of their development. Other pyraustine larvae have been observed to emerge from the stem in which they are feeding to pass through their first larval molt. This habit of migrating apparently works hardship on the species, for doubtless it accounts for the relatively high parasitism in larvae of *Pyrausta ainsliei*.

Egg masses were found to contain anywhere from 2 to 35 eggs. Ressler (*20, p. 278*) records having secured 50 in a single cluster. An average female probably lays 300 to 600 eggs. It is possible to distinguish very young larvae and egg masses of *Pyrausta ainsliei* about to hatch from those of *P. nubilalis* in the same condition wholly on a head capsule comparison. The head capsule of *nubilalis* showing through the transparent corium of the egg when the latter is about to hatch is is always jet black; in *ainsliei* it is a light straw or pale tan color and only assumes its characteristic deep chestnut brown or black color 18 to 24 hours after emergence from the egg.

The following parasites have been reared from *Pyrausta ainsliei* larvae at the Arlington laboratory. This list has been furnished by Dettmar W. Jones: *Microbracon* n. sp.; *Panzeria penitalis* Coq.; *Itoplectis conquisitor* Say; *Bassus agilis* Cress.; *Glypta rufiscutellaris* Cress.; *Ephialtes aequalis* Prov.; *Exorista nigripalpis* Town.; *Rogas rileyi* Cress. *Microgaster epagoges* Gahan is probably a primary parasite of *ainsliei*. Ressler (*20, p. 280*) in Iowa records that he reared a braconid, belonging to the genus Aleoides, from this species. Ainslie and Cartwright reared a predator (*1, p. 844*) in *Callida decora* Fab. They suggest that doubtless larvae of *Chauliognathus pennsylvanicus* De Geer destroy some of the borers; "in two instances they have been found feeding upon the contents of the puparia [doubtless they mean pupae] in the stems."

The larvae are cylindrical, 18.5 mm., or 0.718 inch, in length when full grown (pl. 1, C). They do not vary in color so markedly as the larvae of *P. nubilalis*. The larvae are for the most part slate gray and plumbeous colored on the dorsum and a dirty white ventrad. The head capsule is usually a deep chestnut brown, yet specimens may be had with black head capsules. On hatching from the egg, however, the head capsules of the larvae are always pale.

From an examination of thousands of living specimens at the European Corn Borer Laboratory during 1920 and 1921 it has become evident that Carl Heinrich's (*11*) structural distinction between *Pyrausta ainsliei* and *P. nubilalis* larvae is the only positive one, so similar is the morphology of these larvae. It is a difficult character to establish with a hand lens, owing to the dark pigmentation of the head capsules. This fact, unfortunately, hampers its usefulness for field men. Nevertheless the distinction is always constant and can be used in every instar. Other characters have been tested and tables kept to establish their reliability, such as the shape of the anal plate, the disposition of the clear spaces on the integument, and the distance between certain tubercles on particular abdominal segments, but invariably these have had to be given up because of their inconstancy.

Heinrich's character bears on the arrangement of the setae and the position of the puncture in the anterior epicranial group (*11, p. 178*) (pl. 2, I, J).

Epicranial setae and puncture A^1, A^2, and A^a forming an obtuse angle with A^a postero-dorsad of A^2—*P. ainsliei*.

Epicranial setae and puncture A^1, A^2, and A^a lying in a straight line or with A^a somewhat postero-laterad of A^2, not postero-dorsad—*P. nubilalis*.

Owing to the fact that the head capsules of these larvae are somewhat globose in form it is probable that Heinrich in the latter instance, when he refers to A^1, A^2, and the puncture A^a as lying in a straight line, actually means that their position is along an arc conforming to the declivity of the head.

PYRAUSTA PENITALIS GROTE

Pyrausta penitalis Grote, 1876, Canad. Ent. 8:98; Dyar, 1902, List N. Amer. Lepidop, No. 4439; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer. No. 5129.
Pyrausta nelumbialis Smith, 1890, Ent. Amer. 6:89.

In 1876 Grote described *Pyrausta penitalis* (the Nelumbo borer) from moths reared by Snow, of Lawrence, Kans. In 1890 J. B. Smith described the same species under the appropriate name of *nelumbialis*. He reared moths from larvae taken in the buds, flowers, seed capsules, and leaf and flower stems of the Egyptian lotus, collected at Bordentown, N. J.

During 1920 and 1921 the larvae of *Pyrausta penitalis* (pl. 1, B) were received at the European Corn Borer

Laboratory in the following plants: Egyptian lotus (Weiss, Riverton, N. J.); *Nelumbo lutea* (Wild.) Pers. (Howell, South Bass Island, Ohio); *Polygonum lapathifolium* L. (Craft, Sandusky, Ohio); *Polygonum pennsylvanicum* L. (Howell, Middle Bass Island, Ohio); rhubarb (G. A. Runner, Sandusky, Ohio). The rhubarb contained a great many larvae from the second to the fifth instars which were reared to adult moths. The rhubarb was badly damaged, entirely unfit for marketing. Just as the larvae of *nubilalis* in rhubarb eject gelatinous and gumlike castings from their burrows, so the larvae of *penitalis* feeding in the stems of the same plant push out of their tunnels similar exudations. The discovery of the larvae in rhubarb by Runner is apparently the first record for this species of economic note. F. W. Poos, Sandusky, Ohio, has since established beyond question the fact that the rhubarb in this case was not a host but a shelter plant. A large number of infested Nelumbo blooms were placed near the rhubarb plants. As these wilted the larvae deserted them for the rhubarb. Furthermore, Poos has been unable to rear the larvae on rhubarb and has likewise failed to find additional evidence that this species attacks rhubarb in the open. Vickery found the larvae of *penitalis* frequently in corn at Bay, Ohio, on September 13, 1921. These larvae were full grown and apparently were using the corn, as pointed out for *ainsliei*, as a place of shelter.

The Nelumbo borer is known to occur from Maine south through New Jersey, Washington, D. C., Tennessee and Missouri to Texas, and north through Kansas, Illinois, and Ohio.

Although *Pyrausta penitalis* has been collected in New England, the writer was unable during 1920 and 1921 to locate an infestation of this insect and, consequently, it was not possible to observe it under field conditions. Larvae sent to the Arlington laboratory by various field men in Ohio emerged as moths in the insectary in 1921 over a period of 18 days, from June 9 to June 27. An average of 14.7 days was spent in the pupal stage. Offspring from these moths brought through on *Polygonum pennsylvanicum* L. var. *laevigatum* Fernald were full grown larvae September 10. Howell and Vickery in August, 1921, found larvae commonly in all stages of development in Polygonum in northern Ohio. Apparently there is but one generation in Massachusetts. Poos finds three generations at Sandusky, Ohio.

The larvae have much the same habits as *P. nubilalis* and *P. ainsliei* in that they mine out the pith columns and feed on the medulla of the plants they infest, extruding frass from their burrows. Usually they spend more time in the open after hatching from the eggs than either of the above mentioned species, feeding on the leaf and flower buds, and the tender foliage. In confinement they have been observed to web together immature foliage and to feed therein for a considerable time prior to entering the stems of the plant. The larvae also appear to possess a greater silk-spinning ability than either *nubilalis* or *ainsliei*. When half grown, or before, they enter the plant and form definite burrows. While the larvae possess no particular body modification for aquatic life they are capable of remaining in water for days. In lotus stems they have been submerged for a month without apparent injury. Larvae on the surface film of water attain the sides of the vessel in which they are confined by convulsing the abdominal segments from side to side. Observers have noted that the larvae of this species are not to be found in lotus plants in the autumn, but in hollow reeds or other places of shelter on shore (*2*). To remain in the old lotus or Nelumbo plants as they collapse and fall into the water in the autumn, remaining submerged over the winter, apparently would not make for the welfare of the species. It was noted at Riverton, N. J., in 1918, that old lotus plants practically all disintegrate during the winter.

Coquillett (*4, p. 154*) lists the following parasites of *Pyrausta penitalis: Exorista vulgaris* Fall.; *Hypostena variabilis* Coq.; *Panzeria penitalis* Coq.; *Phorocera comstocki* Will.

Full-grown larvae of this species are larger and more robust than either *Pyrausta nubilalis* or *P. ainsliei*. The pupae are also larger but the adults are smaller than the former, almost equaling in size the moths of the latter. The larvae measure 22.5 mm. or 0.87 inch in length, and are heavily pigmented. They usually are brownish-black on the dorsum and white ventrad. The head capsule is larger than in either of the above forms and has a mottled appearance, owing to the collection of the pigment in small regular areas, leaving the remainder of the chitin light colored. In *ainsliei* the pigmentation of the head is uniformly dark colored. However, in *nubilalis* specimens of the larvae can be found intermediate between *ainsliei* and *penitalis:* in such cases the pigment collects into irregular blotches. Heinrich sepa-

rates *penitalis* from *nubilalis*, as follows:

Epicranial puncture O^a lying postero-dorsad of ocellus VI; mandible longer than broad; distal tooth concaved—*P. penitalis*.

Epicranial puncture O^a lying directly posterior to ocellus VI; mandible square, distal tooth pointed—*P. nubilalis*.

(Pl. 2, I, J.)

PHLYCTAENIA RUBIGALIS GUENÉE

Scopula rubigalis Guen., 1854, Delt. et Pyr. (Bdv. et Guen., Hist. Nat. Ins. Lépidop.) 8: 398.
Botys oblunalis Lederer, 1863, Wien. Ent. Monatschr. 7: 372, 469.
Botys harveyana Grote, 1877, Canad. Ent. 9: 104.
Phlyctaenia ferrugalis auct. (nec Hübner).
Pionea rubigalis Guen. Hampson, 1899, Proc. Zool. Soc. London, 1899: 242.
Phlyctaenia rubigalis Guen., Chittenden, 1901, U. S. Dept. Agr., Div. Ent. Bul. 27: 7; Slingerland, 1901, N. Y. Cornell Agr. Exp. Sta. Bul. 190: 159; Busck and Heinrich, 1925, Jour. Agr. Research 29: 140.

Phlyctaenia rubigalis Guen. (the greenhouse leaf-tyer) is apparently the most widespread and troublesome insect pest with which greenhouse operators have to contend. It is especially troublesome where chrysanthemums are exclusively grown. In New England practically every greenhouse examined in 1920–21 was severely infested by this insect. Although it is primarily a pest of chrysanthemums, it has also been found to attack rose, violet, snapdragon, and geranium. Davis (*5, p. 100*) found in Illinois that chrysanthemum and spearmint were particularly subject to attack. Infestations have also been found in celery, cabbage, beets, lettuce, cauliflower, and strawberry among garden crops. Many more plants, both ornamentals and vegetables, not mentioned here, doubtless are fed upon by the larvae of this species.

In 1921 the moths appeared in numbers in chrysanthemum houses the first week in May. From this time until the blooms and plants were cut in October and November the insect bred continuously. During the months of July, August, and September it was possible, on examination of greenhouse chrysanthemums, to find the insect in all stages of development—eggs, larvae, pupae, and moths. It was practically impossible to follow the broods in the field on account of the overlapping of generations.

After the blooms are marketed in October and November growers cut the old plants back severely, dumping or burning the tops out of doors. The old plants thus pruned soon give forth shoots which are used for the new crop of chrysanthemums the subsequent season. This dumping or burning of the tops reduces in a large measure the infestation, since practically all the developing larvae and pupae are removed from the house. Moreover, the moths flying in the houses have no further place for oviposition, and since it requires a week to 10 days for the old plants to produce shoots the majority of the insects die and the house is rid of the pest. In houses where a variety of ornamentals is grown the insect breeds continuously through the entire year; it is equally abundant in winter and summer. Davis (*5*) noted that the insect was rarely found in greenhouses during the winter months and attributed the fact to the cooler temperatures prevailing in houses in the winter. In the spring, greenhouses are apparently reinfested from moths emerging from the old chrysanthemum tops or litter out of doors, gaining entry through the ventilators. In midseason in 1921 it required 35 days under glass for the insect to complete its development from egg to adult. The larvae usually pupate in the webbed-up leaves.

The larvae (pl. 1, F) for the most part are surface feeders—a few instances have been noted in market gardens and from specimens received at the Arlington laboratory of the entry of the larvae into the stems of celery—feeding on the under surfaces of the leaves of chrysanthemum and also webbing the leaves together with strands of silk, forming thereby an irregular fabrication in which they live. They have also been observed to feed on the leaf buds in the axils of the expanded leaves and on the flower buds, which on opening produce imperfect blooms. When the larvae are numerous this latter type of feeding greatly discounts the market value of the blooms but has no serious effect on the vitality of the plant.

Full-grown larvae slightly resemble the European corn borer in a superficial way. The distribution of the setae on the body is almost identical in both species. Both are pyralids. The larvae measure when full grown 0.68 inch in length. They are pale sage-green in color and strongly translucent, so that portions of the trachea, particularly about the spiracles, may be seen through the cuticula in living specimens. Average specimens bear a dark green stripe on the median dorsal plane and two white broader stripes halfway between the former and the pleura. The head capsule is pale yellow and mottled; the thoracic and anal shields are light yellow. The chitinized areas about the tubercles or

pinacula are pale (*10, p. 142*), indistinct, and sometimes wanting entirely. The chitinization of the pinacula forms the chief character whereby they can be readily separated from the larvae of the corn-borer group.

Two near relatives have been reared at the Arlington laboratory: *Phlyctaenia tertialis* Guen. from elderberry, in which it breeds and overwinters as a larva, and *Phlyctaenia terrealis* Tr. from carnations. The larva of the latter enters the stem of the carnation plant through the crown of terminal leaves. Its presence is readily detected by the wilting of this section of the plant which growers pinch off and unfortunately throw in the walks of their greenhouses. The larvae soon desert these pinched-off parts and return to the living plants to reinfest them. This wilting bears much resemblance to the wilting in certain plants resulting from the attack of the European corn borer, but the latter is not known at this time to infest carnation.

DIATRAEA ZEACOLELLA DYAR

Diatraea zeacolella Dyar, 1911, Ent. News 22: 203; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer. No. 5437.

Previous to Dyar's separation and description of *Diatraea zeacolella* (the larger cornstalk borer) in 1911 entomological writers on economic subjects referred to this insect as *Diatraea saccharalis* Fab., believing the species injuring corn identical with the one doing damage to sugar cane.

The larger cornstalk borer is primarily a southern insect. The records by various workers, especially Leiby (*17, p. 10*), show that it extends from Delaware to Florida, west to Louisiana, and possibly occurs in Kansas, Oklahoma, and Texas. It passes through two complete generations, one in the spring and early summer and the other in late summer and early fall. The overwintering larva pupates in the early spring.

The principal food plant of the insect is the corn plant. Other food plants have been recorded as: Gama grass, sorghum (sorgo), sugar cane (Howard), probably Johnson grass, and Guinea corn (Ainslie).

On hatching from the eggs the larvae feed on the epidermis of the leaves of corn (*17, p. 28*), finally working their way into the unopened whorl of corn leaves which on expanding contain a rather uniformly sized series of holes running across the breadth of the leaf (*19, p. 8*). Another series of irregular perforations in the leaf may also be present when it fully expands, owing to the fact that the larvae feed within the bud in an irregular way, horizontally or upward, or downward. After feeding in either fashion for a time the larvae desert this part of the corn, migrating downward and reentering the plant generally between the first and second joints. Since the insect has two broods and the nature of the feeding for the two generations of larvae is closely parallel, much real injury is caused to growing corn, the growth of the plant being impaired and production being consequently diminished. The larvae apparently never attack the grain on the ear as do those of the European corn borer. "The larger cornstalk borer habitually passes the winter in the taproot of the corn plant, whereas *nubilalis* may be found at any point in the stalk and in the ear" (Caffrey).

Although the larger cornstalk borer possesses many structural characters common to the European corn borer, the two larvae differ quite radically in appearance. The larvae of *Diatraea zeacolella* are of two types, a summer and a winter form. The essential difference between the two types consists in the pigmentation of the pinacula. In the summer form they are brown to black, well defined, in strong contrast to the white body and honey-yellow head. In the winter form these areas have all faded out, are pale, indistinct and seem to fuse with the whiteness of the body. The larvae average 24.9 mm., or almost an inch in length. They are, therefore, slightly longer than *nubilalis*, and more robust.

The supracoxal pinaculum on the mesothorax in Diatraea bears two setae, No. VI [7] (pl. 2, C); in *nubilalis* this same area is unisetose, seta VI (pl. 2, A) (*15, pl. 4, fig. 1*).

[7] Larval chaetotaxy is a difficult study. It is particularly difficult to trace setal homologies. The writer makes no pretense of being well informed on the subject. The Roman numerals employed in designating setae follow the system of Dyar, who did the pioneer work in America on this subject. Heinrich's papers have been freely consulted and studied. Fracker (*10*) has instituted a nomenclature of Greek letters, believing that by its utilization one can more readily grasp the homologies of setae. It seems that Fracker established his homologies by plotting one segment above the other. He failed, however, to take note of the fact that the hairs occur on definite body areas and that their changes in position are caused by modifications of the areas themselves. It has been pointed out clearly by Heinrich that when hairs are absent, as frequently happens on the ninth abdominal segment, it is necessary to trace the folds to determine what body areas have been reduced or crowded aside before one can decide what particular seta is missing. Fracker did not do this and, therefore, frequently has given the wrong designation to his seta. Fracker's system apparently would have been, in many ways, an improvement over the Roman method if he had correctly worked out the homologies between the segments.

NOMOPHILA NOCTUELLA DENIS AND SCHIFFERMÜLLER

Tinea noctuella D. & S., 1776, Syst. Verz. Wien., p. 136.
Pyralis hybridalis Hübn., 1796, Eur. Schmett., Pyr., 29, pl. 17, fig. 114.
Nephopteryx indistinctalis Walk., 1863, Cat. Brit. Mus., pt. 27: 59.
Botys helvolalis Maassen, 1890, Stübel's Reise, p. 170.
Nomophila noctuella D. & S., Dyar, 1902, List N. Amer. Lepidop. No. 4342; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer. No. 5012.

Nomophila noctuella (the celery stalk worm) has been known for a long time, yet notwithstanding its abundance and wide distribution, very few references to it occur in the literature on economic entomology. It is cosmopolitan, occurring in Europe, Algeria, Bengal and the eastern and western parts of the United States.

In 1893 Felt published a paper on this species (7) in which he records the fact that the larvae feed on certain grasses. He also states that Leach in "British Pyralids" records the larvae from *Polygonum aviculare* in Scotland. The interest of the writer in *Nomophila noctuella* is due to its occurrence as a larva on celery in the market gardens in the vicinity of Arlington, Mass. It was found frequently associated with the larvae of *Pyrausta nubilalis* for which it has been mistaken.

Field observations in New England in 1920–21, supported by insectary rearings, indicate that there are two complete generations, the insect passing the winter as a larva in litter. Felt states that in New York there seem to be three broods a year. At Arlington moths emerged in 1921 during the last week in May, the larvae from which, forming the first generation, pupated and emerged over a 3-week period, from July 7 to July 22. The second-brood larvae, for the most part, were mature the third week in September and passed the winter as such. The pupal stage of the first brood was of 13.8 days duration in 1921.

The eggs, 0.37 mm. in diameter, are globular, slightly compressed at either pole, and sculptured. The sculpturing appears much like that on noctuid eggs—a series of radiating prominent ridges from the poles connected to each other by secondary transverse striae which increase in length in the region of the greatest diameter of the egg. The eggs are a dull white and slightly iridescent, this iridescence disappearing as incubation proceeds. At hatching time the eggs are brown, owing to the brown head capsule and thoracic shield of the larva within. The eggs are laid in groups varying from 4 to 48, but are in nowise attached to one another. They are usually to be found on the under sides of the leaves of the plant.

The larvae (pl 1, H) were taken commonly from celery on the grooved side of the celery stalk, and also apparently preferred the blanched and semi-blanched portions of the stalk. Only the outermost stems of the plant were observed to be infested. Since these are discarded when the celery is shipped to market it is doubtful whether the species does perceptible damage to celery. The larvae make irregular, shallow excavations on the stalk, usually covering the area with strands of silk, although instances were found where the feeding was carried on without any silken inclosure over the feeding area. They are surface feeders, never drilling into or tunneling the stalk as is so characteristic of the European corn borer. The larva on being prodded moves forward or backward with equal rapidity.

Full grown larvae measure 0.81 inch in length. They are a pale green or dirty white in color, depending apparently upon what they have been eating. The latter type is invariably found on celery. The head capsule and thoracic shield, as well as the large nearly quadrate areas about the tubercles on the median plane of the back, are chestnut brown. The larvae are distinguished from those of the corn-borer group by the unusually long setae or hairs arising from the pinacula on the segments of the body; in *Pyrausta nubilalis* these setae are comparatively short and stiff. Seta III of the eighth abdominal segment is fully three times the length of the same seta in the European corn borer. Another difference readily noted is in the arrangement of the pinacula on the median plane of the back. These areas are close to those of the opposite half of the larva, and each posterior pair on the abdominal segments follows its antecedents in the same horizontal plane. In the Pyrausta larvae discussed, the posterior median pair of pinacula are laterventrad of horizontal lines drawn through the anterior pair; the four median pinacula on each abdominal segment if connected to one another by an imaginary line would describe a trapezoid on Pyrausta larvae, a parallelogram on those of Nomophila.

LOXOSTEGE SIMILALIS GUENÉE

Nymphula similalis Guen., 1854, Delt. et Pyr. (Bdv. et Guen., Hist. Nat. Ins. Lépidop.) 8: 403.

Nymphula rantalis Guen., 1854, Delt. et Pyr. (Bdv. et Guen., Hist. Nat. Ins. Lépidop.) 8: 405.
Ebulea murcialis Walk., 1859, Cat. Brit. Mus. pt. 18, p. 746.
Scopula crinisalis Walk., 1859, Cat. Brit. Mus., pt. 18, p. 798.
Botys siriusalis Walk., 1859, Cat. Brit. Mus., pt. 18, p. 563.
Botys licealis Walk., 1859, Cat. Brit. Mus., pt. 18, p. 563.
Botys nestusalis Walk., 1859, Cat. Brit. Mus., pt. 18, p. 784.
Scopula thoonalis Walk., 1859, Cat. Brit. Mus., pt. 18, p. 785.
Scopula dictimealis Walk., 1859, Cat. Brit. Mus., pt. 18, p. 785.
Nephopteryx intractella Walk., 1863, Cat. Brit. Mus., pt. 27, p. 55.
Botys posticata G. & R., 1867, Trans. Amer. Ent. Soc. 1: 22.
Scopula occidentalis Pack., 1873, Ann. Lyc. Nat. Hist. N. Y. 10: 260.
Botis communis Grote, 1876, Canad. Ent. 8: 99.
Loxostege similalis Guen., Dyar, 1902, List N. Amer. Lepidop., No. 4354; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 5025.
Pyrausta caffreii Flint and Malloch, 1920, Bul. State Ill. Dept. Reg. & Educ., Div. Nat. Hist. Surv. 13: 304, figs. 43, 44 (vide Heinrich 2, p. 57).

The larva of *Loxostege similalis* (the garden webworm), is a foliage depredator, feeding exclusively in the open or in an irregular fabrication formed by webbing leaves together with silk. It is not a borer as is the European corn borer, yet it resembles the former in appearance. The greatest resemblance is structurally, the distribution of the setae on the thoracic and abdominal segments being most alike. The insect occurs in most of the Central, Western, and Southern States, but can also be found in Mexico and South America. It is particularly damaging in California, Nebraska, Iowa, Missouri, New Mexico, Kansas, Oklahoma, and Texas. In the three last-named States second and third annual cuttings of alfalfa have been entirely destroyed in certain years.[8]

The garden webworm, apparently incorrectly named since it injures to a large extent cereal and forage crops, feeds on and injures beets, sugar beets, potatoes, corn, cotton, wheat, alfalfa, and, doubtless, garden crops. Its natural food appears to be *Amaranthus* sp. (pigweed), and *Chenopodium* sp. (lamb's-quarters). Since the year 1909 the injury to alfalfa has steadily increased, becoming more serious and widespread.

A striking difference between this larva and those of the corn-borer group is the habit which the caterpillar of Loxostege has, when full grown, of descending from its food plant to the surface of the soil, where it forms a small silken cocoon in the litter and within this it pupates. The European corn borer, as a rule, pupates within its burrow and never forms a defined cocoon.

The larva is green-brown in color and three-fourths to seven-eighths of an inch in length. The pinacula on the dorsum are strongly chitinized, brown to black, and prominent; those on the pleura are pale and not so strongly chitinized. In Pyrausta larvae heretofore discussed the pinacula on the various parts of the body are uniform with respect to one another in color and chitinization; there is no distinction between those of the dorsum and those on the pleura. In *nubilalis* Seta IV+V on the ninth abdominal segment almost equals Seta III in size; in *similalis* IV+V is small and vestigial (pl. 2, A, E).

In the latitude of Kansas and Oklahoma the insect apparently passes through four generations, whereas in Texas it seems to breed continuously throughout the year, summer and winter.

FAMILY OLETHREUTIDAE

EPIBLEMA SCUDDERIANA CLEMENS

Hedya scudderiana Clemens, 1860, Proc. Acad. Nat. Sci. Phila. 12: 358.
Eurytychia saligneana Clemens, 1865, Proc. Ent. Soc. Phila. 5: 141.
Paedisca affusana Zeller, 1875, Verh. Zool.-Bot. Ges. Wien 25: 307.
Paedisca scudderiana Kellicott, 1882, Canad. Ent. 14: 161; Walsingham, 1884, Trans. Ent. Soc. London, 1884: 140.
Eucosma scudderiana Clemens, Fernald, 1902, Dyar, List. N. Amer. Lepidop., No. 5139; Kearfoot, 1905, Proc. U. S. Nat. Mus. 28: 354; 1905, Canad. Ent. 37: 208; Barnes and McDunnough, 1917, Check List Lepidop. Bor Amer., No. 7014.
Epiblema scudderiana Clemens, Heinrich, 1923, U. S. Nat. Mus. Bul. 123: 147, fig. 271.

Epiblema scudderiana (the Bidens borer) is common throughout eastern Massachusetts and doubtless occurs in equal numbers over the North Atlantic States. Specimens have been received at the European Corn Borer Laboratory from Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Ohio, and Michigan. With the exception of two records, one occurrence in lamb's-quarters (*Chenopodium* sp.) and one from burdock (*Arctium* sp.) the insect has been collected only from beggar-ticks (*Bidens frondosa*) and goldenrod (*Solidago* sp.).

Field observations indicate that the insect is single brooded in Massachusetts. In 1921 moths appeared the third week in June, the overwintering

[8] Information as to the distribution, food plants, and seasonal history was obtained from Farmers' Bulletin 944 (*16*).

larvae pupating the first week and throughout the month of June and early July. Young larvae were found as early as June 28 in Bidens plants. The majority of the larvae in the field were full grown the third week in September, 1921. The larvae remain over the winter in their food plants. The character of the injury to Bidens by Epiblema coincides to a considerable degree with that caused by the European corn borer to the same weed. The diameter of the tunnels or burrows in the plant is smaller, however, and the frass extruded therefrom is never in so large a quantity, nor does it adhere to the plant beneath the entrance to the burrows, usually collecting on the soil at the base of the plant in small cone-shaped heaps.

The yellowish-white caterpillars (pl. 1, A) bear a superficial likeness to the immature stages of the European corn borer. Since both species infest Bidens and since the larvae of the two bear prominent dark-colored pinacula, confusion of the species is possible. On close examination of the larvae, however, one readily sees that the structural characters are different. The single ranked crochets on the pseudopods are arranged on the planta in a completed circle, whereas those of the Pyraustinae are of three ranks and are arranged in an imperfect circle or imperfect ellipse, sometimes referred to as a penellipse with the opening to the horseshoe outermost. This olethreutid bears three setae on the prespiracular pinaculum, whereas pyralid and noctuid larvae bear only two setae on this structure. There is no pigmented band or stripe on the median dorsal plane of the larvae of *Epiblema scudderiana*. Other less evident differences exist, such as the shape of the mandible, the structure of the maxillae, and the setal arrangement on the head capsule.

EPIBLEMA STRENUANA WALKER

Grapholita strenuana Walk., 1863, Cat. Lepidop Het. Brit. Mus., 28: 383.
Grapholita exvagana Walk., 1863, Cat. Lepidop. Het. Brit. Mus., 28: 383.
Steganoptycha flavocellana Clemens, 1865, Proc. Ent. Soc. Phila., 5: 138.
Graptholitha subversana Zeller, 1875, Verh. Zool.-Bot. Ges. Wien 25: 318.
Paedisca strenuana Walk., Wals., 1879, Illus. Lepidop. Het. Brit. Mus., 4: 52; 1884, Trans. Ent. Soc. London, 1884: 140.
Eucosma strenuana Walk., Fernald, 1902, Dyar, List N. Amer. Lepidop., No. 5129; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 6981.
Eucosma minutana Kearfott, 1905, Proc. U. S. Nat. Mus. 28: 356; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 6982.
Eucosma antaxia Meyrick, 1920, Exot. Microlepidop. 2 (*11*): 344.
Epiblema strenuana Walk., Heinrich, 1923, U. S. Nat. Mus. Bul. 123: 140, figs. 257, 258.

The larve of *Epiblema strenuana* (the ragweed borer) has been taken only from *Ambrosia artemisiaefolia* L. (ragweed) (*14, p. 141*). Apparently it is not common in eastern Massachusetts. It differs from the previous species of Epiblema in having the pinacula on the thorax and abdominal segments feebly pigmented; the setae are pale yellow; the thoracic and anal shields pale; the head light brown in lieu of black. It can be distinguished from the European corn borer and other pyralids by the characters enumerated under *scudderiana*.

FAMILY OECOPHORIDAE

DEPRESSARIA HERACLIANA DE GEER

Phalaena heracliana De Geer, 1771, Mém. Ins. 2: 407.
Phalaena heraclei Retz., 1783, De Geer, Gen. et Spec. Ins., p. 45.
Pyralis umbellana Fab., 1794, Ent. Syst., pt. 2, 3: 286.
Haemylis pastinacella Dupon., 1836, Hist. Nat. 8: 153.
Haemylis umbellella Zett., 1840, Ins. Lapp., p. 999.
Depressaria ontariella Bethune, 1869, Canad. Ent. 2: 3.
Depressaria heracliana De Geer, Dyar, 1902, List N. Amer. Lepidop., No. 5889; Busck, 1902, Proc. U. S. Nat. Mus. 24: 748; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 1478.

Depressaria heracliana (the parsnip webworm) is a European species imported into this country probably in the late sixties of the last century. It was, at any rate, first noticed in 1873 as of economic importance, and has since distributed itself over the northern portions of the United States, west and south to the State of Mississippi and in Canada. It has been named the parsnip webworm from the habit which the larva possesses of webbing up the flower and seed heads of the parsnip. The insect breeds on wild carrot and probably on other umbelliferous plants.

The larvae (pl. 1, E) of this species were observed in 1921 at Cliftondale, Mass. They were found living in masses and feeding on the flower heads of parsnip, which they had webbed together with strands of silk. In time this nestlike structure becomes dirty and foul from the collection of excreta. When the larvae were one-half to three-fourths grown, they were observed gradually to desert their feeding quarters externally and enter the parsnip stalk, although some remained in the original web and pupated therein. The majority, however, tunneled through the cortex and thin white medulla of the

plant, feeding in groups on the latter tissue, which lines the hollow stem. The larvae cover their entrances through which they pass into the stalk with tympana of silk. Later the moths rupture these structures as they emerge from the stalk. When full grown, the larva spins a pad of silk against the inside wall of the stem, in which one finds the cremaster of the pupa securely fastened, thus suspending the larval head downward. In 1921, under insectary conditions, the insect remained as a pupa 12.7 days. The moths appeared in mid-July and continued to emerge into August.

Full-grown larvae are slightly smaller than the larvae of *Pyrausta nubilalis*, to which they bear resemblance. The black head, thoracic shield, and pinacula of the body segment sharply contrast with the yellowish-white integument of the larva. The anal shield is lemon yellow. The dorsal surface is granulated, but the skin granulations are never as dense as in the larvae of Pyrausta. The prespiracular pinacula bear three setae, the chitinous rings of the spiracles are stout and black, the crochets on the planta of the pseudopods are in a completed circle, and the setal arrangement on the ninth abdominal segment differs from that of all the larvae previously discussed in this paper (pl. 2, D).

FAMILY NOCTUIDAE

HELIOTHIS OBSOLETA FAB.

Bombyx obsoleta Fab., 1793, Ent. Syst., pt. 1 3:456.
Noctua armiger Hübn., 1810, Samml. Eur. Schmett., Noct., 370.
Heliothis armiger Hübn., Dyar, 1902, List No. Amer. Lepidop., No. 2300.
Chloridea armigera Hübn., Hampson, 1903, Cat. Lepidop. Phal. Brit. Mus., 4:45.
Heliothis obsoleta Fab., Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 1090.

Although the larva of the corn earworm (*Heliothis obsoleta* Fab.) primarily attacks the grain on the ear of field and sugar corn, it is also known to feed freely on the silk and sparingly on the foliage. The European corn borer attacks all parts of the plant. It habitually lives within burrows made in the stalk, in the midrib of the leaf, on the ear, and in the cob. The corn earworm never drills through the tough fibrous cortex of the corn plant or into the cob. When the insect attacks cotton, however, the larva bores into the boll, destroying the lint and the seeds. Both the corn borer and the earworm feed on the corn kernels, but the larva of the latter invariably enters at the tip end, whereas the corn borer enters the ear at every conceivable point, such as through the tip, through the side, and through the butt, and very frequently, indeed, it lives in the pith of the cob. Caffrey has noted that the breaking over of tassels in a cornfield does not necessarily preclude feeding in these parts by the corn borer, since he has found that the earworm is capable of occasionally doing the very same thing, particularly in late-developing sweet corn. The corn earworm is a most important destructive pest. Estimates have been made of an annual loss of from 2 to 5 per cent of the total corn crop produced in the United States, or of $30,000,000 to $50,000,000. The insect occurs throughout the United States and in many parts of the world.

In addition to the injury inflicted by the earworm to corn, it attacks such important crops as tobacco and cotton. Tomatoes, beans, forage plants, and many others are periodically damaged. The caterpillars are large, robust forms belonging to the same family of insects as the cutworms. They are exceedingly variable in color, ranging from green to rose, brown to black, striped, spotted, or plain. Thus in a field one may collect larvae which to the layman or to the farmer would seem entirely different. When the larvae have completed their growth they fall or descend of their own accord to the soil, burrow 2 to 5 inches into it, and construct cells wherein they pupate. The corn borer never enters the soil to pupate but transforms in its burrow or in another place of seclusion to which it has migrated. In the Gulf States there are four broods of the earworm annually, along the Gulf coast there may be five or six, whereas in the northern States there are two, with possibly only one in the province of Ontario, Canada. In Massachusetts in 1921 the corn earworm was abundant and destructive.

The larvae are larger than those of the European corn borer, measuring when fully grown 1¼ to 1½ inches in length. The dorsal pinacula are small, pale, or black, depending on whether the larva is light or dark colored; the supraspiracular pinacula on the pleura are always black or deep brown. The crotchets on the prolegs are characteristically noctuid (pl. 2, M) in a mesoseries. In the European corn borer, as pointed out elsewhere, the crochets are arranged in an incompleted circle with the opening outermost. The head capsule of the corn earworm is yellow-brown and mottled, whereas in the corn borer the head capsule is usually

black or a deep chestnut brown and is always black as the larva emerges from the egg. Just as the larvae of the corn borer group have only two setae, IV and V, on the prespiracular pinacula of the prothorax, so on this point the noctuids are structurally identical, but on the third, fourth, fifth, and sixth abdominal segments the setal distribution differs with respect to IV and V; IV is removed quite a distance from V and is directly caudad of the spiracle (pl. 2, H).

ACHATODES ZEAE HARRIS

Gortyna zeae Harris, 1841, Ins. Mass. Inj. Veg., p. 319.
Achatodes zeae Harris, Dyar, 1902, List N. Amer. Lepidop., No. 2158; Barnes and McDunnough, 1917, Check List Lepidop. Bor. Amer., No. 2642.

Since Harris described *Achatodes zeae* (the spindleworm) and the injury to corn caused by its larva, infrequent references have been made to it in entomological literature. Forbes in his classical Twenty-third Report gives an account of it (*9, p. 85*) and characterizes it as the spindleworm, apparently from the fact that it has been found attacking corn in the so-called spindle stage of that plant.

The species is very abundant everywhere in Massachusetts in elderberry, but has only rarely been seen attacking corn. Dyar (*6, p. 174*) gives its distribution as the North Atlantic States. On May 28, 1921, eight young larvae were found in an equal number of sweet corn plants, but this corn was not advanced to the spindle stage. The corn was in proximity to a large growth of elderberry. The larvae found in the stalks were in well-defined burrows and were headed upward in these tunnels. The latter are very similar in appearance to those of the European corn borer, but in the above case the seasonal occurrence of Achatodes larvae did not synchronize with the latter. The plants were badly wilted as if from Papaipema attack.

The natural food plant of this species is elderberry in which the larvae have been found in large numbers. On May 17, 1921, it was possible to cut out, from new elderberry shoots springing from the soil, quantities of the larvae. On June 10 they were found in all stages of development. The first pupae were taken in the burrows June 16 and subsequently some were found which pupated in the soil, but pupation occurs largely in the burrows where the larvae developed. The pupae are large, reddish-brown and are supplied with two prominent processes on the cephalic end.

The larva (pl. 1, G) is striking in appearance. Head, thoracic and anal shields, and the pinacula are glossy black; the body of the larva is yellowish-white. On all the abdominal segments, with the exception of the ninth, the two anterior median pinacula are larger than those of the caudal pair; the anterior pair are circular in contour, the caudal pair elliptical. On the ninth abdominal segment the anterior set equals the posterior pair in size.

The larva of this species may be distinguished from other larvae treated in this paper by an examination of the anal shield. This is strongly chitinized, black, rugose, and bears on its caudal margin three pairs or a row of prominent and strongly produced spines.

KEY TO THE SEPARATION OF LARVAE TREATED HERETOFORE

1. Larvae without strongly produced spines on the anal shield 2
   Larvae with strongly produced spines on the anal shield ..... *Achatodes zeae*
2. Larvae with three setae on prespiracular shield 3
   Larvae with two setae on prespiracular shield 4
3. Setae III and V on prespiracular shield small, indistinct, much smaller than Seta IV ..... *Epiblema scudderiana*
   Setae III and V on prespiracular shield prominent, well defined, equal to Seta IV in size ..... *Depressaria heracliana*
4. Crochets on planta of pseudopods arranged in an incomplete circle or penellipse 5
   Crochets arranged otherwise; in mesoseries ..... *Heliothis obsoleta*
5. Seta III of the eighth abdominal segment normal sized; pinacula bearing Setae VII and VIII, respectively, on the eighth abdominal segment wanting, poorly defined or only lightly chitinized 6
   Seta III of the eighth abdominal segment abnormally long, terminating short of the caudal border of the ninth abdominal segment; pinacula bearing Setae VII and VIII, respectively, on the eighth abdominal segment well defined, strongly chitinized ..... *Nomophila noctuella*
6. Pinacula on body segments pale and indefinite (*D. zeacolella*, winter form) 7
   Pinacula on body segments strongly chitinized, well defined, and heavily pigmented 8

7. Supracoxal pinacula on the mesothorax furnished with one seta (Seta No. VI)---*Phlyctaenia rubigalis*
   Supracoxal pinacula on mesothorax furnished with two setae (Seta No. VI)---*Diatraea zeacolella*
8. Seta IV and V on the subdorsal pinaculum of the ninth abdominal segment small and nearly obsolete, this pinaculum bearing one large seta which is III---*Loxostege similalis*
   Seta IV and V on the subdorsal pinaculum of the ninth abdominal segment large, almost equal in size to III---9
9. (*11, p. 178*) "Epicranial setae and puncture A^1, A^2, and A^a lying in a straight line or with A^a somewhat postero-laterad of A^2, not postero-dorsad"---10
   "Epicranial setae and puncture A^1, A^2, and A^a forming an obtuse angle with A^a postero-dorsad of A^2---*P. ainsliei*
10. "Epicranial puncture O^a lying postero-dorsad of Ocellus VI; mandible longer than broad; distal tooth concaved"---*P. penitalis*
    "Epicranial puncture O^a lying directly posterior to Ocellus VI; mandible square; distal tooth pointed"---*P. nubilalis*

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